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DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648-XC624

Takes of Marine Mammals Incidental to Specified Activities; Low-Energy Marine Geophysical Survey in the Tropical Western Pacific Ocean, September to October 2013

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice; proposed Incidental Harassment Authorization; request for comments.

SUMMARY: NMFS has received an application from the Scripps Institution of Oceanography (SIO), a part of the University of California at San Diego, for an Incidental Harassment Authorization (IHA) to take marine mammals, by harassment, incidental to conducting a low-energy marine geophysical (seismic) survey in the tropical western Pacific Ocean, September to October 2013. Pursuant to the Marine Mammal Protection Act (MMPA), NMFS is requesting comments on its proposal to issue an IHA to SIO to incidentally harass, by Level B harassment only, 26 species of marine mammals during the specified activity.

DATES: Comments and information must be received no later than [insert date 30 days after date of publication in the FEDERAL REGISTER].

ADDRESSES: Comments on the application should be addressed to P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910. The mailbox address for providing email comments is ITP.Goldstein@noaa.gov. NMFS is not responsible for e-mail comments sent to addresses other than the one provided here. Comments sent via email, including all attachments, must not exceed a 10-megabyte file size.

All comments received are a part of the public record and will generally be posted to http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications without change. All Personal Identifying Information (for example, name, address, etc.) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

A copy of the application containing a list of the references used in this document may be obtained by writing to the above address, telephoning the contact listed here (see FOR FURTHER INFORMATION CONTACT) or visiting the internet at: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

The National Science Foundation (NSF) and SIO have provided a "Draft Environmental Analysis of a Low-Energy Marine Geophysical Survey by the R/V Roger Revelle in the Tropical Western Pacific Ocean, September-October 2013" (EA), prepared by LGL Ltd., Environmental Research Associates, on behalf of NSF and SIO, which is also available at the same Internet address. Documents cited in this notice may be viewed, by appointment, during regular business hours, at the aforementioned address.

FOR FURTHER INFORMATION CONTACT: Howard Goldstein or Jolie Harrison, Office of Protected Resources, NMFS, 301-427-8401.

SUPPLEMENTARY INFORMATION:

Background

Section 101(a)(5)(D) of the MMPA, as amended (16 U.S.C. 1371 (a)(5)(D)), directs the Secretary of Commerce (Secretary) to authorize, upon request, the incidental, but not intentional, taking of small numbers of marine mammals of a species or population stock, by United States citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings are made and, if the taking is limited to harassment, a notice of a proposed authorization is provided to the public for review.

Authorization for the incidental taking of small numbers of marine mammals shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the mitigation, monitoring and reporting of such takings. NMFS has defined "negligible impact" in 50 CFR 216.103 as "…an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival."

Section 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. Section 101(a)(5)(D) of the MMPA establishes a 45-day time limit for NMFS's review of an application followed by a 30-day public notice and comment period on any proposed authorizations for the incidental harassment of small numbers of marine mammals. Within 45 days of the close of the public comment period, NMFS must either issue or deny the authorization.

Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment].

Summary of Request

On April 5, 2013, NMFS received an application from the SIO requesting that NMFS issue an IHA for the take, by Level B harassment only, of small numbers of marine mammals incidental to conducting a low-energy marine seismic survey in International Waters (i.e., high seas) and in the Exclusive Economic Zone of the Federated States of Micronesia (Micronesia), the Independent State of Papua New Guinea (Papua New Guinea), the Republic of Indonesia (Indonesia), and the Republic of the Philippines (Philippines) during September to October 2013. The SIO plans to use one source vessel, the R/V Roger Revelle (Revelle), and a seismic airgun array to collect seismic data in the tropical western Pacific Ocean. The SIO plans to use conventional low-energy, seismic methodology to fill gaps in equatorial Pacific data sets, namely the lack of high-resolution records from the eastern part of the Western Pacific Warm Pool to better assess controls on the hydrologic cycle in the Western Pacific Warm Pool, and a limited meridional coverage to test hypotheses related to the Plio-Pleistocene evolution of the Western Pacific Warm Pool. In addition to the proposed operations of the seismic airgun array and hydrophone streamer, SIO intends to operate a multibeam and sub-bottom profiler continuously throughout the survey.

Acoustic stimuli (i.e., increased underwater sound) generated during the operation of the seismic airgun array may have the potential to cause a behavioral disturbance for marine mammals in the survey area. This is the principal means of marine mammal taking associated with these activities, and SIO has requested an authorization to take 26 species of marine mammals by Level B harassment. Take is not expected to result from the use of the multibeam and sub-bottom profiler, for reasons discussed in this notice; nor is take expected to result from collision with the source vessel because it is a single vessel moving at a relatively slow speed 5 knots [kts]; 11.1 kilometers per hour [km/hr]; 6.9 miles per hour [mph]) during seismic acquisition within the survey, for a relatively short period of time (approximately 26 operational days). It is likely that any marine mammal would be able to avoid the vessel.

Description of the Proposed Specified Activity

SIO proposes to conduct low-energy seismic and sediment coring surveys at 10 sites in the tropical western Pacific Ocean in September to October 2013. The study sites are located between approximately 4º South to 8º North and approximately 126.5 to 144.5º East in international waters (i.e., high seas) and in the Exclusive Economic Zones (EEZ) of the Federated States of Micronesia (Micronesia), the Independent State of Papua New Guinea (Papua New Guinea), the Republic of Indonesia (Indonesia), and the Republic of the Philippines (Philippines) (see Figure 1 of the IHA application). Water depths in the survey area range from 450 to 3,000 meters (m) (1,476.4 to 9,842.5 feet [ft]). The seismic surveys are scheduled to occur for 14 to 20 hours at each of the 10 sites for approximately 26 operational days in September to October 2013. Some minor deviation from these dates would be possible, depending on logistics and weather.

The proposed surveys would fill gaps in equatorial Pacific data sets, namely the lack of high-resolution records from the eastern part of the Western Pacific Warm Pool to better assess the controls on the hydrologic cycle in the Western Pacific Warm Pool, and a limited meridional coverage to test hypotheses related to the Plio-Pleistocene evolution of the Western Pacific Warm Pool. To achieve the project's goals, the Principal Investigators, Drs. Y. Rosenthal and G. Mountain of Rutgers University propose to collect low-energy, high-resolution multi-channel seismic profiles and sediment cores in the heart of the Western Pacific Warm Pool. Survey data would also be included in a research proposal submitted to the Integrated Ocean Drilling Program (IODP) for funding consideration to extend the record of millennial climate variability in the western equatorial Pacific Ocean back to the mid-Miocene. Survey and site characterization data would assist the IODP in determining the viability of the sites for potential future drilling.

The procedures to be used for the surveys would be similar to those used during previous seismic surveys by SIO and would use conventional seismic methodology. The proposed survey will involve one source vessel, the R/V Roger Revelle (Revelle). SIO will deploy two (each with a discharge volume of 45 cubic inch [in^3] with a total volume of 90 in^3) Generator Injector (GI) airgun array as an energy source at a tow depth of 2 m (6.6 ft). The receiving system will consist of one 600 m (1,968.5 ft) long hydrophone streamer. As the GI airguns are towed along the survey lines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the onboard processing system.

Straight survey lines would be collected in a grid of intersecting lines. Seven sites would be centered in small 9 x 9 km (4.9 x 4.9 nmi) grids of six intersecting lines (see Figure 1 of the IHA application). One site warrants slightly longer lines and would be surveyed in a large 18 x 18 km (9.7 x 9.7 nmi) grid of six intersection lines (see Figure 1 of the IHA application). Finally, sites S-1a and S-1b are close enough that efficiency in ship use would be achieved by covering both with a single grid of intersecting lines in a 30 x 26 km (16.2 x 14 nmi). Individual survey lines in this grid would be approximately 5 to 10 km (2.7 to 5.4 nmi) apart. The total track distance of survey data, including turns, would be approximately 1,033 km (557.8 nmi). Barring re-organization because of weather considerations or results that develop from data analyzed as sites are completed, sites would be surveyed in the order summarized in Table 1 (Table 1 of the IHA application).

All planned seismic data acquisition activities will be conducted by technicians provided by SIO with onboard assistance by the scientists who have proposed the study. The vessel will be self-contained, and the crew will live aboard the vessel for the entire cruise.

The planned seismic survey (e.g., equipment testing, startup, line changes, repeat coverage of any areas, and equipment recovery) will consist of approximately 1,032.9 kilometer (km) (557.7 nautical miles [nmi]) of transect lines (including turns) in the survey area in the tropical western Pacific Ocean (see Figure 1 of the IHA application). In addition to the operation of the airgun array, a multibeam echosounder and a sub-bottom profiler will also likely be operated from the Revelle continuously throughout the cruise between the first and last survey sites. There will be additional seismic operations associated with equipment testing, ramp-up, and possible line changes or repeat coverage of any areas where initial data quality is sub-standard. In SIO's estimated take calculations, 25% has been added for those additional operations.

Table 1. Survey patterns and lengths at each proposed survey site in the tropical western Pacific Ocean during September to October 2013.

Survey Site	Survey Pattern (km)	Survey Length (km)
WP-5	9 x 9 (4.9 x 4.9 nmi)	82.2 (44.4 nmi)
WP-6	9 x 9 (4.9 x 4.9 nmi)	82.2 (44.4 nmi)
S-1a, S-1b	30 x 26 (16.2 x 14)	349.5 (188.7)
WP-3	9 x 9 (4.9 x 4.9 nmi)	82.2 (44.4 nmi)
WP-4	9 x 9 (4.9 x 4.9 nmi)	82.2 (44.4 nmi)
WP-2	9 x 9 (4.9 x 4.9 nmi)	82.2 (44.4 nmi)
WP-1	9 x 9 (4.9 x 4.9 nmi)	82.2 (44.4 nmi)
WP-7	9 x 9 (4.9 x 4.9 nmi)	82.2 (44.4 nmi)
WP-8	18 x 18 (9.7 x 9.7 nmi)	108 (58.3 nmi)
Total		1,032.9 (557.7 nmi)

[1] Sites are listed in the intended order in which surveys would be conducted.

Vessel Specifications

The Revelle, a research vessel owned by the U.S. Navy and operated by SIO of the University of California San Diego, will tow the two GI airgun array, as well as the hydrophone streamer, along predetermined lines (see Figure 1 of the IHA application). When the Revelle is towing the airgun array and the relatively short hydrophone streamer, the turning rate of the vessel while the gear is deployed is much higher than the limit of 5 degrees per a minute for a seismic vessel towing a streamer of more typical length (much greater than 1 km [0.5 nmi]), which is approximately 20 degrees. Thus, the maneuverability of the vessel is not limited much during operations with the streamer.

The vessel has a length of 83 m (272.3 ft); a beam of 16.0 m (52.5 ft); a maximum draft of 5.2 m (9.5 ft); and a gross tonnage of 3,180. The ship is powered by two 3,000 horsepower (hp) Propulsion General Electric motors and a 1,180 hp azimuthing jet bowthruster. The Revelle's operation speed during seismic acquisition is typically approximately 9.3 km per hour (hr) (km/hr) (5 knots [kts]). When not towing seismic survey gear, the Revelle typically cruises at 22.2 to 23.1 km/hr (12 to 12.5 kts) and has a maximum speed of 27.8 km/hr (15 kts). The Revelle has an operating range of approximately 27,780 km (15,000 nmi) (the distance the vessel can travel without refueling).

The vessel also has two locations as likely observation stations from which Protected Species Observers (PSO) will watch for marine mammals before and during the proposed airgun operations on the Revelle. Observing stations will be at the 02 level with PSO's eye level approximately 10.4 m (34 ft) above sea level – one forward on the 02 deck commanding a forward-centered, approximately 240º view around the vessel, and one atop the aft hangar, with an aft-centered view that includes the radii around the airguns. The eyes on the bridge watch will be at a height of approximately 15 m (49 ft); PSOs will work on the enclosed bridge and adjoining aft steering station during any inclement weather. More details of the Revelle can be found in the IHA application.

Acoustic Source Specifications

Seismic Airguns

The Revelle will deploy an airgun array, consisting of two 45 in^3 GI airguns as the primary energy source and a 600 m streamer containing hydrophones along predetermined lines. The airgun array will have a firing pressure of 1,750 pounds per square inch (psi). Discharge intervals depend on both the ship's speed and Two Way Travel Time recording intervals. Seismic pulses for the GI airguns will be emitted at intervals of approximately 10 seconds (25 m [82 ft]). At speeds of approximately 11.1 km/hr, the shot intervals correspond to spacing of approximately will be 18.5 to 31 m (60.7 to 101.7 ft) during the study. During firing, a brief (approximately 0.03 second) pulse sound is emitted; the airguns will be silent during the intervening periods. The dominant frequency components range from zero to 188 Hertz (Hz).

The generator chamber of each GI airgun in the primary source, the one responsible for introducing the sound pulse into the ocean, is 45 in^3. The injector chamber injects air into the previously-generated bubble to maintain its shape, and does not introduce more sound into the water. The two GI airguns will be towed 8 m (26.2 ft) apart, side-by-side, 21 m (68.9 ft) behind the Revelle, at a depth of 2 m (6.6 ft) during the surveys. The total effective volume will be 90 in^3.

Metrics Used in this Document

This section includes a brief explanation of the sound measurements frequently used in the discussions of acoustic effects in this document. Sound pressure is the sound force per unit area, and is usually measured in micropascals (μPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. Sound pressure level (SPL) is expressed as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure level in underwater acoustics is 1 μPa, and the units for SPLs are dB re: 1 μPa. SPL (in decibels [dB]) = 20 log (pressure/reference pressure).

SPL is an instantaneous measurement and can be expressed as the peak, the peak-peak (p-p), or the root mean square (rms). Root mean square, which is the square root of the arithmetic average of the squared instantaneous pressure values, is typically used in discussions of the effects of sounds on vertebrates and all references to SPL in this document refer to the root mean square unless otherwise noted. SPL does not take the duration of a sound into account.

Characteristics of the Airgun Pulses

Airguns function by venting high-pressure air into the water which creates an air bubble. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by the oscillation of the resulting air bubble. The oscillation of the air bubble transmits sounds downward through the seafloor and the amount of sound transmitted in the near horizontal directions is reduced. However, the airgun array also emits sounds that travel horizontally toward non-target areas.

The nominal downward-directed source levels of the airgun arrays used by SIO on the Revelle do not represent actual sound levels that can be measured at any location in the water. Rather they represent the level that would be found 1 m (3.3 ft) from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns will not exceed the source level of the strongest individual source. In this case, that will be about 224.6 dB re 1 μPam peak, or 229.8 dB re 1 μPam peak-to-peak. However, the difference between rms and peak or peak-to-peak values for a given pulse depends on the frequency content and duration of the pulse, among other factors. Actual levels experienced by any organism more than 1 m from either GI airgun will be significantly lower.

Accordingly, Lamont-Doherty Earth Observatory of Columbia University (L-DEO) has predicted and modeled the received sound levels in relation to distance and direction from the two GI airgun array. A detailed description of L-DEO's modeling for this survey's marine seismic source arrays for protected species mitigation is provided in the NSF/USGS PEIS. These are the nominal source levels applicable to downward propagation. The NSF/USGS PEIS discusses the characteristics of the airgun pulses. NMFS refers the reviewers to that documents for additional information.

Predicted Sound Levels for the Airguns

To determine exclusion zones for the airgun array to be used in the intermediate and deep water of the Gulf of Mexico (GOM), received sound levels have been modeled by L-DEO for a number of airgun configurations, including two 45 in^3 GI airguns, in relation to distance and direction from the airguns (see Figure 2 of the IHA application). The model does not allow for bottom interactions, and is most directly applicable to deep water. Based on the modeling, estimates of the maximum distances from the GI airguns where sound levels of 180 and 160 dB re 1 µPa (rms) are predicted to be received in intermediate and deep water are shown in Table 2 (see Table 2 of the IHA application).

Empirical data concerning the 180 and 160 dB (rms) distances were acquired for various airgun arrays based on measurements during the acoustic verification studies conducted by L-DEO in the northern GOM in 2003 (Tolstoy et al., 2004) and 2007 to 2008 (Tolstoy et al., 2009; Diebold et al., 2010). Results of the 18 and 36 airgun array are not relevant for the two GI airguns to be used in the proposed survey. The empirical data for the 6, 10, 12, and 20 airgun arrays indicate that, for deep water, the L-DEO model tends to overestimate the received sound levels at a given distance (Tolstoy et al., 2004). Measurements were not made for the two GI airgun array in deep water; however, SIO proposes to use the buffer and exclusion zones predicted by L-DEO's model for the proposed GI airgun operations in deep water, although they are likely conservative given the empirical results for the other arrays. Using the L-DEO model, Table 1 (below) shows the distances at which two rms sound levels are expected to be received from the two GI airguns. The 180 dB re 1 µPam (rms) distances are the safety criteria for potential Level A harassment as specified by NMFS (2000) and are applicable to cetaceans. If marine mammals are detected within or about to enter the appropriate exclusion zone, the airguns will be shut-down immediately.

Table 2 summarizes the predicted distances at which sound levels (160 and 180 dB [rms]) are expected to be received from the two airgun array operating in intermediate (100 to 1,000 m [328 to 3,280 ft]) and deep water (greater than 1,000 m [3,280 ft]) depths.

Table 2**.** Predicted and modeled (two 45 in^3 GI airgun array) distances to which sound levels ≥ 180 and 160 dB re: 1 µPa (rms) could be received in intermediate and deep water during the proposed survey in the tropical western Pacific Ocean, September to October, 2013.

Source and Total Volume	Tow Depth (m)	Water Depth (m)	Predicted RMS Radii Distances (m) for 2 GI Airgun Array	
			160 dB	180 dB
Two GI Airguns (90 in^3)	2	Intermediate (100 to 1,000)	600 (1,968.5 ft)	100 (328ft)
Two GI Airguns (90 in^3)	2	Deep (> 1,000)	400 (1,312.3 ft)	100 (328 ft)

Along with the airgun operations, two additional acoustical data acquisition systems may be operated from the Revelle continuously during the survey. The ocean floor will be mapped with the Kongsberg EM 122 multibeam echosounder and a Knudsen Chirp 3260 sub-bottom profiler. This sound source would be operated continuously from the Revelle throughout the cruise between the first and last survey sites.

Multibeam Echosounder

The Revelle will operate a Kongsberg EM 122 multibeam echosounder to map the ocean floor. The multibeam echosounder operates at 10.5 to 13 (usually 12) kilohertz (kHz) and is hull-mounted. The transmitting beamwidth is 1 or 2º fore-aft and 150º athwartship. The maximum source level is 242 dB (rms). Each 'ping' consists of eight (in water greater than

1,000 m [3,281 ft]) or four (in water less than 1,000 m) successive fan-shaped transmissions, each ensonifying a sector that extends 1º fore-aft. Continuous-wave signals increase from 2 to 15 milliseconds (ms) in water depths up to 2,600 m (8,530 ft), and FM chirp signals up to 100 ms long are used in water greater than 2,600 m (8,530 ft). The successive transmission span an overall cross-track angular extent of about 150º, with 2 ms gaps between the pings for successive sectors.

Sub-Bottom Profiler

The Revelle will operate a Knudsen 3260 sub-bottom profiler continuously throughout the cruise simultaneously to map and provide information about the seafloor sedimentary features and bottom topography that is mapped simultaneously with the multibeam echosounder. The beam of the sub-bottom profiler is transmitted as a 27° cone, which is directed downward by a 3.5 kHz transducer in the hull of the Revelle. The nominal power output is 10 kilowatt (kW), but the actual maximum radiated power is 3 kW or 222 dB (rms). The ping duration is up to 64 ms, and the ping interval is 1 second. A common mode of operation is a broadcast five pulses at 1 second intervals followed by a 5 second pause. The sub-bottom profiler is capable of reaching depths of 10,000 m (32,808.4ft).

NMFS expects that acoustic stimuli resulting from the proposed operation of the two GI airgun array has the potential to harass marine mammals. NMFS does not expect that the movement of the Revelle, during the conduct of the seismic survey, has the potential to harass marine mammals because of the relatively slow operation speed of the vessel (approximately 5 kts; 9.3 km/hr; 5.8 mph) during seismic acquisition.

Piston Core, Gravity Core, and Multicore Description and Deployment

The piston corer to be used on the Revelle consists of a piston core with a 10 cm (in) diameter steel barrel up to approximately 18 m (59.1 ft) long with a 2,300 kilogram (kg) (5,070.6

pounds [lb]) weight and a trigger core with a 10 cm (3.9 inches [in]) diameter PVC plastic barrel 3 m (9.8 ft) long with a 230 kg (507.1 lb) weight, which are lowered concurrently into the ocean floor with 1.4 cm (0.6 in) diameter steel cables.

The gravity core consists of a 6 m (19.7 ft) long core pipe that takes a core sample approximately 10 cm in diameter, a head weight approximately 45 cm (17.7 in) in diameter, and a stabilizing fin. It is lowered to the ocean floor with a 1.4 cm diameter steel cable at 100 m/minute (328.1 ft/min) speed.

The multicore consists of an outer 8-legged cone shaped frame and a weighted inner frame that holds up to 8 plastic core sampling tubes 80 cm (31.5 in) long and approximately 10 cm in diameter. The outer frame is lowered to the bottom, and inner frame is then released to allow the sampling tubes to penetrate the sediment. At each of the 10 sites, one of each type of core would be collected.

Dates, Duration, and Specified Geographic Region

The proposed project and survey sites are located between approximately 4º South to 8º North and approximately 126.5 to 144.5º East in International Waters and in the EEZs of Micronesia, Papua New Guinea, Indonesia, and the Philippines (see Figure 1 of the IHA application). Water depths in the survey area range from approximately 450 to 3,000 m (1,476.4 to 9,842.5 ft). The Revelle is expected to depart from Lae, Papua New Guinea on September 6, 2013 and arrive at Manila, Philippines on October 1, 2013 (see Table 1 of the IHA application for the proposed order of survey sites. Seismic operations would take approximately 14 to 20 hours at each of the 10 sites, and total transit time to the first site, between all sites, and from the last site would be approximately 13 days. The remainder of the time, approximately 6 days, would be spent collecting sediment cores at the 10 sites, for a total of 26 operational days. Some minor deviation from this schedule is possible, depending on logistics and weather (i.e., the cruise may depart earlier or be extended due to poor weather; there could be additional days of seismic operations if collected data are deemed to be of substandard quality).

Description of the Marine Mammals in the Area of the Proposed Specified Activity

The marine mammal species that potentially occur within the tropical western Pacific Ocean include 26 species of cetaceans and one sirenian. In addition to the 26 species known to occur in the tropical western Pacific Ocean, there are three species known to occur in coastal waters of the study area, these include the Australian snubfin dolphin (Orcaella heinsohni), Indo-Pacific humpback dolphin (Sousa chinensis), and the Indo-Pacific bottlenose dolphin (Tursiops aduncus). However, these species do not occur in in slope or deep, offshore waters where the proposed activities would take place. Those three species are not considered further in this document. No pinnipeds are known to occur in the proposed study area.

The marine mammals that generally occur in the proposed action area belong to three taxonomic groups: mysticetes (baleen whales), odontocetes (toothed whales), and sirenians (the dugong). Marine mammal species listed as endangered under the U.S. Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 et seq.), includes the humpback (Megaptera novaeangliae), sei (Balaenoptera borealis), fin (Balaenoptera physalus), blue (Balaenoptera musculus), and sperm (Physeter macrocephalus) whale, as well as the dugong. Of those endangered species, the humpback, sei, fin, blue, and sperm whale is likely to be encountered in the proposed survey area. The dugong (Dugong dugon) is the one marine mammal species mentioned in this document that is managed by the U.S. Fish and Wildlife Service (USFWS) and is not considered further in this analysis; all others are managed by NMFS.

Few systematic surveys have been conducted in the tropical western Pacific Ocean, and none have taken place during September to October. Borsa and Nugroho (2010) conducted 1,561 km (842.9 nmi) of surveys of Raja Ampat waters, including the Halmahera Sea, in West

Papua during November to December 2007. Visser (2002 in Visser and Bonoccorso, 2003) conducted preliminary surveys in Kimbe Bay, New Britain, Papua New Guinea. Miyazaki and Wada (1978) surveyed 11,249 km (6,074nmi) in the wider tropical Pacific, including Micronesia, and the waters off Papua New Guinea and the Solomon Islands during January to March 1976. Shimada and Miyashita (2001) conducted 8,721 km (4,709 nmi) of surveys in Micronesia, the Solomon Islands, and north of Papua New Guinea during February to March from 1999 to 2001. Oremus (2011) described 4,523 km (2,442.2 nmi) of surveys in the Solomon Islands during November of 2009 and 2010. Dolar et al. (2006) surveyed the waters of the central Philippines, including the Sulu Sea, during May to June 1994 and 1995; 2,747 km (1,483.3 nmi) were covered. In May 1996, Dolar et al. (1997) surveyed 825 km (445.5 nmi) in the southern Sulu Sea. Another survey of relevance to the proposed survey area is one that took place during January to April 2007 in the waters of Guam and the Commonwealth of the Northern Mariana Islands; a total of 11,033 km (5,957.3 nmi) were surveyed in the area 10 to 18º North and 142 to 148º East (SRS-Parsons, 2007; Fulling et al., 2011). The aforementioned surveys took place in shallow coastal waters as well as deeper offshore waters. Records from the Ocean Biogeographic Information System (OBIS) database hosted by Rutgers and Duke University (Read et al., 2009) were also considered. Table 3 (below) presents information on the abundance, distribution, population status, conservation status, and population trend of the species of marine mammals that may occur in the proposed study area during September to October, 2013.

Table 3. The habitat, regional abundance, and conservation status of marine mammals that may occur in or near the proposed seismic survey area in the tropical western Pacific Ocean (See text and Table 3 in SIO's application for further details).

Species	Habitat	Population Estimate	ESA[1]	MMPA[2]
Mysticetes				
Humpback whale (Megaptera novaeangliae)	Pelagic, nearshore waters, and banks	3,520[3]	EN	D
Minke whale (Balaenoptera acutorostrata)	Pelagic and coastal	25,000[4]	NL	NC
Bryde's whale (Balaenoptera edeni)	Pelagic and coastal	21,000[5]	NL	NC
Omura's whale (Balaenoptera omurai)	Pelagic and coastal	NA	NL	NC
Sei whale (Balaenoptera borealis)	Primarily offshore, pelagic	7,260 to 12,620[6]	EN	D
Fin whale (Balaenoptera physalus)	Continental slope, pelagic	13,620 to 18,680[7]	EN	D
Blue whale (Balaenoptera musculus)	Pelagic, shelf, coastal	NA	EN	D
Odontocetes				
Sperm whale (Physeter macrocephalus)	Pelagic, deep sea	29,674[8]	EN	D
Pygmy sperm whale (Kogia breviceps)	Deep waters off the shelf	NA	NL	NC
Dwarf sperm whale (Kogia sima)	Deep waters off the shelf	11,200[9]	NL	NC
Cuvier's beaked whale (Ziphius cavirostris)	Pelagic	20,000[9]	NL	NC
Longman's beaked whale (Indopacetus pacificus)	Pelagic	NA	NL	NC
Ginkgo-toothed beaked whale (Mesoplodon ginkgodens)	Pelagic	25,300[10]	NL	NC
Blainville's beaked whale (Mesopldon densirostris)	Pelagic	25,300[10]	NL	NC
Killer whale (Orcinus orca)	Pelagic, shelf, coastal	8,500[9]	NL	NC
Short-finned pilot whale	Pelagic, shelf coastal	53,608[12]	NL	NC

(Globicephala macrorhynchus)				
False killer whale (Pseudorca crassidens)	Pelagic	16,668[12]	NL	NC
Melon-headed whale (Peponocephala electra)	Pelagic	45,400[9]	NL	NC
Pygmy killer whale (Feresa attenuata)	Pelagic	38,900[9]	NL	NC
Risso's dolphin (Grampus griseus)	Deep water, seamounts	83,289[12]	NL	NC
Bottlenose dolphin (Tursiops truncatus)	Offshore, inshore, coastal, estuaries	168,792[12]	NL	NC
Rough-toothed dolphin (Steno bredanensis)	Pelagic	107,633[11]	NL	NC
Fraser's dolphin (Lagenodelphis hosei)	Pelagic	289,300[9]	NL	NC
Striped dolphin (Stenella coeruleoalba)	Pelagic	570,038[13]	NL	NC
Pantropical spotted dolphin (Stenella attenuata)	Coastal, pelagic	438,064[11]	NL	NC
Spinner dolphin (Stenella longirostris)	Coastal, pelagic	734,837[13]	NL	NC
Sirenians				
Dugong (Dugong dugon)	Coastal	NA	EN	D

NA = Not available or not assessed.
[1] U.S. Endangered Species Act: EN = Endangered, T = Threatened, DL = Delisted, NL = Not listed.
[2] U.S. Marine Mammal Protection Act: D = Depleted, S = Strategic, NC = Not Classified.
[3] Oceania (Constantine et al., 2010).
4 Northwest Pacific and Okhotsk Sea (IWC, 2013).
5 Western North Pacific (IWC, 2013).
6 North Pacific (Tillman, 1977).
7 North Pacific (Ohsumi and Wada, 1974).
8 Western North Pacific (Whitehead, 2002).
9 Eastern Tropical Pacific (Wade and Gerrodette, 1993).
10 Eastern Tropical Pacific, all Mesoplodon spp. (Wade and Gerrodette, 1993)
11 Eastern Tropical Pacific (Gerrodette et al., 2008).
12 Western North Pacific (Miyashita, 1993).
13 Whitebelly stock in Eastern Tropical Pacific (Gerrodette et al., 2008).

Refer to sections 3 and 4 of SIO's application for detailed information regarding the abundance and distribution, population status, and life history and behavior of these other marine mammal species and their occurrence in the proposed project area. The application also presents how SIO calculated the estimated densities for the marine mammals in the proposed survey area. NMFS has reviewed these data and determined them to be the best available scientific information for the purposes of the proposed IHA.

Potential Effects on Marine Mammals

Acoustic stimuli generated by the operation of the airguns, which introduce sound into the marine environment, may have the potential to cause Level B harassment of marine mammals in the proposed survey area. The effects of sounds from airgun operations might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al., 1995; Gordon et al., 2004; Nowacek et al., 2007; Southall et al., 2007). Permanent hearing impairment, in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not an injury (Southall et al., 2007). Although the possibility cannot be entirely excluded, it is unlikely that the proposed project would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. Based on the available data and studies described here, some behavioral disturbance is expected. A more comprehensive review of these issues can be found in the "Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement prepared for Marine Seismic Research that is funded by the National Science Foundation and conducted by the U.S. Geological Survey" (NSF/USGS, 2011).

Tolerance

Richardson et al. (1995) defines tolerance as the occurrence of marine mammals in areas where they are exposed to human activities or man-made noise. In many cases, tolerance develops by the animal habituating to the stimulus (i.e., the gradual waning of responses to a repeated or ongoing stimulus) (Richardson, et al., 1995; Thorpe, 1963), but because of ecological or physiological requirements, many marine animals may need to remain in areas where they are exposed to chronic stimuli (Richardson, et al., 1995).

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of the marine mammal group. Although various baleen whales and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times marine mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

Masking

The term masking refers to the inability of a subject to recognize the occurrence of an acoustic stimulus as a result of the interference of another acoustic stimulus (Clark et al., 2009). Introduced underwater sound may, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson et al., 1995).

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited. Because of the intermittent nature and low duty cycle of seismic airgun pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in some situations, reverberation occurs for much or the entire interval between pulses (e.g., Simard et al., 2005; Clark and Gagnon, 2006) which could mask calls. Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls can usually be heard between the seismic pulses (e.g., Richardson et al., 1986; McDonald et al., 1995; Greene et al., 1999; Nieukirk et al., 2004; Smultea et al., 2004; Holst et al., 2005a,b, 2006; and Dunn and Hernandez, 2009). However, Clark and Gagnon (2006) reported that fin whales in the North Atlantic Ocean went silent for an extended period starting soon after the onset of a seismic survey in the area. Similarly, there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al., 1994). However, more recent studies found that they continued calling in the presence of seismic pulses (Madsen et al., 2002; Tyack et al., 2003; Smultea et al., 2004; Holst et al., 2006; and Jochens et al., 2008). Dilorio and Clark (2009) found evidence of increased calling by blue whales during operations by a lower-energy seismic source (i.e., sparker). Dolphins and porpoises commonly are heard calling while airguns are operating (e.g., Gordon et al., 2004; Smultea et al., 2004; Holst et al., 2005a, b; and Potter et al., 2007). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, NMFS expects the masking effects of seismic pulses to be minor, given the normally intermittent nature of seismic pulses.

Behavioral Disturbance

Marine mammals may behaviorally react to sound when exposed to anthropogenic noise. Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al., 1995; Wartzok et al., 2004; Southall et al., 2007; Weilgart, 2007). These behavioral reactions are often shown as: changing durations of surfacing and dives, number of blows per surfacing, or moving direction and/or speed; reduced/increased vocal activities; changing/cessation of certain behavioral activities (such as socializing or feeding); visible startle response or aggressive behavior (such as tail/fluke slapping or jaw clapping); avoidance of areas where noise sources are located; and/or flight responses. If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder, 2007; Weilgart, 2007).

The biological significance of many of these behavioral disturbances is difficult to predict, especially if the detected disturbances appear minor. However, the consequences of behavioral modification could be expected to be biologically significant if the change affects growth, survival, and/or reproduction. Some of these significant behavioral modifications include:

- Change in diving/surfacing patterns (such as those thought to be causing beaked whale stranding due to exposure to military mid-frequency tactical sonar);
- Habitat abandonment due to loss of desirable acoustic environment; and
- Cessation of feeding or social interaction.

The onset of behavioral disturbance from anthropogenic noise depends on both external factors (characteristics of noise sources and their paths) and the receiving animals (hearing, motivation, experience, demography) and is also difficult to predict (Richardson et al., 1995; Southall et al., 2007). Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically-important manner.

Baleen Whales - Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable (reviewed in Richardson et al., 1995; Gordon et al., 2004). Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals (Richardson, et al., 1995). They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors.

Studies of gray, bowhead, and humpback whales have shown that seismic pulses with received levels of 160 to 170 dB re 1 μPa (rms) seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed (Malme et al., 1986, 1988; Richardson et al., 1995). In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 4 to 15 km (2.2 to 8.1 nmi) from the source. A substantial proportion of the baleen whales within those distances may show avoidance or other strong behavioral reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and studies have shown that some species of baleen whales, notably bowhead, gray, and humpback whales, at times, show strong avoidance at received levels lower than 160 to 170 dB re 1 μPa (rms).

Researchers have studied the responses of humpback whales to seismic surveys during migration, feeding during the summer months, breeding while offshore from Angola, and wintering offshore from Brazil. McCauley et al. (1998, 2000a) studied the responses of humpback whales off western Australia to a full-scale seismic survey with a 16 airgun array (2,678 in^3) and to a single airgun (20 in^3) with source level of 227 dB re 1 μPa (p-p). In the 1998 study, they documented that avoidance reactions began at 5 to 8 km (2.7 to 4.3 nmi) from the array, and that those reactions kept most pods approximately 3 to 4 km (1.6 to 2.2 nmi) from the operating seismic boat. In the 2000 study, they noted localized displacement during migration of 4 to 5 km (2.2 to 2.7 nmi) by traveling pods and 7 to 12 km (3.8 to 6.5 nmi) by more sensitive resting pods of cow-calf pairs. Avoidance distances with respect to the single airgun were smaller but consistent with the results from the full array in terms of the received sound levels. The mean received level for initial avoidance of an approaching airgun was 140 dB re 1 μPa (rms) for humpback pods containing females, and at the mean closest point of approach distance the received level was 143 dB re 1 μPa (rms). The initial avoidance response generally occurred at distances of 5 to 8 km (2.7 to 4.3 nmi) from the airgun array and 2 km (1.1 nmi) from the single airgun. However, some individual humpback whales, especially males, approached within distances of 100 to 400 m (328 to 1,312 ft), where the maximum received level was 179 dB re 1 μPa (rms).

Data collected by observers during several seismic surveys in the Northwest Atlantic showed that sighting rates of humpback whales were significantly greater during non-seismic periods compared with periods when a full array was operating (Moulton and Holst, 2010). In addition, humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst, 2010).

Humpback whales on their summer feeding grounds in southeast Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 1.64-L (100 in^3) airgun (Malme et al., 1985). Some humpbacks seemed "startled" at received levels of 150 to 169 dB re 1 μPa. Malme et al. (1985) concluded that there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 dB re 1 μPa (rms). However, Moulton and Holst (2010) reported that humpback whales monitored during seismic surveys in the Northwest Atlantic had lower sighting rates and were most often seen swimming away from the vessel during seismic periods compared with periods when airguns were silent.

Studies have suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al., 2004). The evidence for this was circumstantial and subject to alternative explanations (IAGC, 2004). Also, the evidence was not consistent with subsequent results from the same area of Brazil (Parente et al., 2006), or with direct studies of humpbacks exposed to seismic surveys in other areas and seasons. After allowance for data from subsequent years, there was "no observable direct correlation" between strandings and seismic surveys (IWC, 2007: 236).

Reactions of migrating and feeding (but not wintering) gray whales to seismic surveys have been studied. Malme et al. (1986, 1988) studied the responses of feeding eastern Pacific gray whales to pulses from a single 100 in^3 airgun off St. Lawrence Island in the northern Bering

Sea. They estimated, based on small sample sizes, that 50 percent of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10 percent of feeding whales interrupted feeding at received levels of 163 dB re 1 μPa (rms). Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast (Malme et al., 1984; Malme and Miles, 1985), and western Pacific gray whales feeding off Sakhalin Island, Russia (Wursig et al., 1999; Gailey et al., 2007; Johnson et al., 2007; Yazvenko et al., 2007a, b), along with data on gray whales off British Columbia (Bain and Williams, 2006).

Various species of Balaenoptera (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses (Stone, 2003; MacLean and Haley, 2004; Stone and Tasker, 2006), and calls from blue and fin whales have been localized in areas with airgun operations (e.g., McDonald et al., 1995; Dunn and Hernandez, 2009; Castellote et al., 2010). Sightings by observers on seismic vessels off the United Kingdom from 1997 to 2000 suggest that, during times of good sightability, sighting rates for mysticetes (mainly fin and sei whales) were similar when large arrays of airguns were shooting vs. silent (Stone, 2003; Stone and Tasker, 2006). However, these whales tended to exhibit localized avoidance, remaining significantly further (on average) from the airgun array during seismic operations compared with non-seismic periods (Stone and Tasker, 2006). Castellote et al. (2010) reported that singing fin whales in the Mediterranean moved away from an operating airgun array.

Ship-based monitoring studies of baleen whales (including blue, fin, sei, minke, and humpback whales) in the Northwest Atlantic found that overall, this group had lower sighting rates during seismic vs. non-seismic periods (Moulton and Holst, 2010). Baleen whales as a group were also seen significantly farther from the vessel during seismic compared with non-seismic periods, and they were more often seen to be swimming away from the operating seismic vessel (Moulton and Holst, 2010). Blue and minke whales were initially sighted significantly farther from the vessel during seismic operations compared to non-seismic periods; the same trend was observed for fin whales (Moulton and Holst, 2010). Minke whales were most often observed to be swimming away from the vessel when seismic operations were underway (Moulton and Holst, 2010).

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades (Appendix A in Malme et al., 1984; Richardson et al., 1995; Allen and Angliss, 2010). The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year (Johnson et al., 2007). Similarly, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years (Richardson et al., 1987; Allen and Angliss, 2010). The history of coexistence between seismic surveys and baleen whales suggests that brief exposures to sound pulses from any single seismic survey are unlikely to result in prolonged effects.

Toothed Whales - Little systematic information is available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above have been reported for toothed whales. However, there are recent systematic studies on sperm whales (e.g., Gordon et al., 2006; Madsen et al., 2006; Winsor and Mate, 2006; Jochens et al., 2008; Miller et al., 2009). There is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone, 2003; Smultea et al., 2004; Moulton and Miller, 2005; Bain and Williams, 2006; Holst et al., 2006; Stone and Tasker, 2006; Potter et al., 2007; Hauser et al., 2008; Holst and Smultea, 2008; Weir, 2008; Barkaszi et al., 2009; Richardson et al., 2009; Moulton and Holst, 2010).

Seismic operators and PSOs on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Goold, 1996a,b,c; Calambokidis and Osmek, 1998; Stone, 2003; Moulton and Miller, 2005; Holst et al., 2006; Stone and Tasker, 2006; Weir, 2008; Richardson et al., 2009; Barkaszi et al., 2009; Moulton and Holst, 2010). Some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing (e.g., Moulton and Miller, 2005). Nonetheless, small toothed whales more often tend to head away, or to maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Stone and Tasker, 2006; Weir, 2008; Barry et al., 2010; Moulton and Holst, 2010). In most cases, the avoidance radii for delphinids appear to be small, on the order of one km or less, and some individuals show no apparent avoidance.

Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al., 2000, 2002, 2005). However, the animals tolerated high received levels of sound before exhibiting aversive behaviors.

Most studies of sperm whales exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses (e.g., Stone, 2003; Moulton et al., 2005, 2006a; Stone and Tasker, 2006; Weir, 2008). In most cases the whales do not show strong avoidance, and they continue to call. However, controlled exposure experiments in the Gulf of Mexico indicate that foraging behavior was altered upon exposure to airgun sound (Jochens et al., 2008; Miller et al., 2009; Tyack, 2009).

There are almost no specific data on the behavioral reactions of beaked whales to seismic surveys. However, some northern bottlenose whales (Hyperoodon ampullatus) remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (Gosselin and Lawson, 2004; Laurinolli and Cochrane, 2005; Simard et al., 2005). Most beaked whales tend to avoid approaching vessels of other types (e.g., Wursig et al., 1998). They may also dive for an extended period when approached by a vessel (e.g., Kasuya, 1986), although it is uncertain how much longer such dives may be as compared to dives by undisturbed beaked whales, which also are often quite long (Baird et al., 2006; Tyack et al., 2006). Based on a single observation, Aguilar-Soto et al. (2006) suggested that foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels. In any event, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel, although this has not been documented explicitly. In fact, Moulton and Holst (2010) reported 15 sightings of beaked whales during seismic studies in the Northwest Atlantic; seven of those sightings were made at times when at least one airgun was operating. There was little evidence to indicate that beaked whale behavior was affected by airgun operations; sighting rates and distances were similar during seismic and non-seismic periods (Moulton and Holst, 2010).

There are increasing indications that some beaked whales tend to strand when naval exercises involving mid-frequency sonar operation are ongoing nearby (e.g., Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; NOAA and USN, 2001; Jepson et al., 2003; Hildebrand, 2005; Barlow and Gisiner, 2006; see also the "Stranding and Mortality" section in this notice). These strandings are apparently a disturbance response, although auditory or other injuries or other physiological effects may also be involved. Whether beaked whales would ever react similarly to seismic surveys is unknown. Seismic survey sounds are quite different from those of the sonar in operation during the above-cited incidents.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids and Dall's porpoises, seem to be confined to a smaller radius than has been observed for the more responsive of some mysticetes. However, other data suggest that some odontocete species, including harbor porpoises, may be more responsive than might be expected given their poor low-frequency hearing. Reactions at longer distances may be particularly likely when sound propagation conditions are conducive to transmission of the higher frequency components of airgun sound to the animals' location (DeRuiter et al., 2006; Goold and Coates, 2006; Tyack et al., 2006; Potter et al., 2007).

Hearing Impairment and Other Physical Effects

Exposure to high intensity sound for a sufficient duration may result in auditory effects such as a noise-induced threshold shift - an increase in the auditory threshold after exposure to noise (Finneran, Carder, Schlundt, and Ridgway, 2005). Factors that influence the amount of threshold shift include the amplitude, duration, frequency content, temporal pattern, and energy distribution of noise exposure. The magnitude of hearing threshold shift normally decreases over time following cessation of the noise exposure. The amount of threshold shift just after exposure is called the initial threshold shift. If the threshold shift eventually returns to zero (i.e., the threshold returns to the pre-exposure value), it is called temporary threshold shift (TTS) (Southall et al., 2007).

Researchers have studied TTS in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed in Southall et al., 2007). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., permanent threshold shift (PTS), in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Temporary Threshold Shift - TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals, and none of the published data concern TTS elicited by exposure to multiple pulses of sound. Available data on TTS in marine mammals are summarized in Southall et al. (2007). Table 2 (above) presents the estimated distances from the Revelle's airguns at which the received energy level (per pulse, flat-weighted) would be expected to be greater than or equal to 180 dB re 1 μPa (rms).

To avoid the potential for injury, NMFS (1995, 2000) concluded that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa (rms). NMFS believes that to avoid the potential for Level A harassment, cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa (rms), respectively. The established 180 dB (rms) criteria are not considered to be the levels above which TTS might occur. Rather, they are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals.

For toothed whales, researchers have derived TTS information for odontocetes from studies on the bottlenose dolphin and beluga. The experiments show that exposure to a single impulse at a received level of 207 kPa (or 30 psi, p-p), which is equivalent to 228 dB re 1 Pa (p-p), resulted in a 7 and 6 dB TTS in the beluga whale at 0.4 and 30 kHz, respectively. Thresholds returned to within 2 dB of the pre-exposure level within 4 minutes of the exposure (Finneran et al., 2002). For the one harbor porpoise tested, the received level of airgun sound that elicited onset of TTS was lower (Lucke et al., 2009). If these results from a single animal are representative, it is inappropriate to assume that onset of TTS occurs at similar received levels in all odontocetes (cf. Southall et al., 2007). Some cetaceans apparently can incur TTS at considerably lower sound exposures than are necessary to elicit TTS in the beluga or bottlenose dolphin.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are assumed to be lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison, 2004). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales than those of odontocetes (Southall et al., 2007).

Permanent Threshold Shift - When PTS occurs, there is physical damage to the sound receptors in the ear. In severe cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985). There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al., 1995, p. 372ff; Gedamke et al., 2008). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS.

Relationships between TTS and PTS thresholds have not been studied in marine mammals but are assumed to be similar to those in humans and other terrestrial mammals (Southall et al., 2007). PTS might occur at a received sound level at least several dBs above that inducing mild TTS if the animal were exposed to strong sound pulses with rapid rise times. Based on data from terrestrial mammals, a precautionary assumption is that the PTS threshold for impulse sounds (such as airgun pulses as received close to the source) is at least 6 dB higher than the TTS threshold on a peak-pressure basis, and probably greater than 6 dB (Southall et al., 2007).

Given the higher level of sound necessary to cause PTS as compared with TTS, it is considerably less likely that PTS would occur. Baleen whales generally avoid the immediate area around operating seismic vessels, as do some other marine mammals.

Stranding and Mortality – When a living or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is termed a "stranding" (Geraci et al., 1999; Perrin and Geraci, 2002; Geraci and Lounsbury, 2005; NMFS, 2007). The legal definition for a stranding under the MMPA is that "(A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance."

Marine mammals are known to strand for a variety of reasons, such as infectious agents, biotoxicosis, starvation, fishery interaction, ship strike, unusual oceanographic or weather events, sound exposure, or combinations of these stressors sustained concurrently or in series. However, the cause or causes of most strandings are unknown (Geraci et al., 1976; Eaton, 1979; Odell et al., 1980; Best, 1982). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Chroussos, 2000; Creel, 2005; DeVries et al., 2003; Fair and Becker, 2000; Foley et al., 2001; Moberg, 2000; Relyea, 2005a, 2005b; Romero, 2004; Sih et al., 2004).

Strandings Associated with Military Active Sonar – Several sources have published lists of mass stranding events of cetaceans in an attempt to identify relationships between those stranding events and military active sonar (Hildebrand, 2004; IWC, 2005; Taylor et al., 2004). For example, based on a review of stranding records between 1960 and 1995, the International Whaling Commission (2005) identified ten mass stranding events and concluded that, out of eight stranding events reported from the mid-1980s to the summer of 2003, seven had been coincident with the use of mid-frequency active sonar and most involved beaked whales.

Over the past 12 years, there have been five stranding events coincident with military mid-frequency active sonar use in which exposure to sonar is believed to have been a contributing factor to strandings: Greece (1996); the Bahamas (2000); Madeira (2000); Canary Islands (2002); and Spain (2006). Refer to Cox et al. (2006) for a summary of common features shared by the strandings events in Greece (1996), Bahamas (2000), Madeira (2000), and Canary Islands (2002); and Fernandez et al., (2005) for an additional summary of the Canary Islands 2002 stranding event.

Potential for Stranding from Seismic Surveys – Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al., 1993; Ketten, 1995). However, explosives are no longer used in marine waters for commercial seismic surveys or (with rare exceptions) for seismic research. These methods have been replaced entirely by airguns or related non-explosive pulse generators. Airgun pulses are less energetic and have slower rise times, and there is no specific evidence that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of strandings of beaked whales with naval exercises involving mid-frequency active sonar (non-pulse sound) and, in one case, the co-occurrence of an L-DEO seismic survey (Malakoff, 2002; Cox et al., 2006), has raised the possibility that beaked whales exposed to strong "pulsed" sounds could also be susceptible to injury and/or behavioral reactions that can lead to stranding (e.g., Hildebrand, 2005; Southall et al., 2007).

Specific sound-related processes that lead to strandings and mortality are not well documented, but may include:

(1) Swimming in avoidance of a sound into shallow water;

(2) A change in behavior (such as a change in diving behavior) that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive hemorrhage or other forms of trauma;

(3) A physiological change such as a vestibular response leading to a behavioral change or stress-induced hemorrhagic diathesis, leading in turn to tissue damage; and

(4) Tissue damage directly from sound exposure, such as through acoustically-mediated bubble formation and growth or acoustic resonance of tissues.

Some of these mechanisms are unlikely to apply in the case of impulse sounds. However, there are indications that gas-bubble disease (analogous to "the bends"), induced in supersaturated tissue by a behavioral response to acoustic exposure, could be a pathologic mechanism for the strandings and mortality of some deep-diving cetaceans exposed to sonar. The evidence for this remains circumstantial and associated with exposure to naval mid-frequency sonar, not seismic surveys (Cox et al., 2006; Southall et al., 2007).

Seismic pulses and mid-frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses. Sounds produced by airgun arrays are broadband impulses with most of the energy below one kHz. Typical military mid-frequency sonar emits non-impulse sounds at frequencies of 2 to 10 kHz, generally with a relatively narrow bandwidth at any one time. A further difference between seismic surveys and naval exercises is that naval exercises can involve sound sources on more than one vessel. Thus, it is not appropriate to expect that the same to marine mammals will result from military sonar and seismic surveys. However, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g., Balcomb and Claridge, 2001; NOAA and USN, 2001; Jepson et al., 2003; Fernández et al., 2004, 2005; Hildebrand 2005; Cox et al., 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity sound.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al., 2004) were not well founded (IAGC, 2004; IWC, 2007). In September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the L-DEO vessel R/V Maurice Ewing was operating a 20 airgun (8,490 in^3) array in the general area. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002). Nonetheless, the Gulf of California incident plus the beaked whale strandings near naval exercises involving use of mid-frequency sonar suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand, 2005). No injuries of beaked whales are anticipated during the proposed study because of:

(1) The high likelihood that any beaked whales nearby would avoid the approaching vessel before being exposed to high sound levels, and

(2) Differences between the sound sources operated by L-DEO and those involved in the

naval exercises associated with strandings.

Non-auditory Physiological Effects - Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance, and other types of organ or tissue damage (Cox et al., 2006; Southall et al., 2007). Studies examining such effects are limited. However, resonance effects (Gentry, 2002) and direct noise-induced bubble formations (Crum et al., 2005) are implausible in the case of exposure to an impulsive broadband source like an airgun array. If seismic surveys disrupt diving patterns of deep-diving species, this might perhaps result in bubble formation and a form of the bends, as speculated to occur in beaked whales exposed to sonar. However, there is no specific evidence of this upon exposure to airgun pulses.

In general, very little is known about the potential for seismic survey sounds (or other types of strong underwater sounds) to cause non-auditory physical effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. The available data do not allow identification of a specific exposure level above which non-auditory effects can be expected (Southall et al., 2007), or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects.

Potential Effects of Other Acoustic Devices

Multibeam Echosounder

SIO will operate the Kongsberg EM 122 multibeam echosounder from the source vessel during the planned study. Sounds from the multibeam echosounder are very short pulses, occurring for 2 to 15 ms once every 5 to 20 seconds, depending on water depth. Most of the energy in the sound pulses emitted by the multibeam echosounder is at frequencies near 12 kHz, and the maximum source level is 242 dB re 242 dB re 1 μPa (rms). The beam is narrow (1 to 2º) in fore-aft extent and wide (150º) in the cross-track extent. Each ping consists of eight (in water greater than 1,000 m deep) or four (in water less than 1,000 m deep) successive fan-shaped transmissions (segments) at different cross-track angles. Any given mammal at depth near the trackline would be in the main beam for only one or two of the nine segments. Also, marine mammals that encounter the Kongsberg EM 122 are unlikely to be subjected to repeated pulses because of the narrow fore–aft width of the beam and will receive only limited amounts of pulse energy because of the short pulses. Animals close to the ship (where the beam is narrowest) are especially unlikely to be ensonified for more than one 2 to 15 ms pulse (or two pulses if in the overlap area). Similarly, Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when a multibeam echosounder emits a pulse is small. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to cause TTS.

Navy sonars that have been linked to avoidance reactions and stranding of cetaceans: (1) generally have longer pulse duration than the Kongsberg EM 122; and (2) are often directed close to horizontally versus more downward for the multibeam echosounder. The area of possible influence of the multibeam echosounder is much smaller - a narrow band below the source vessel. Also, the duration of exposure for a given marine mammal can be much longer for naval sonar. During SIO's operations, the individual pulses will be very short, and a given mammal would not receive many of the downward-directed pulses as the vessel passes by.

Possible effects of a multibeam echosounder on marine mammals are described below.

Masking - Marine mammal communications will not be masked appreciably by the multibeam echosounder signals given the low duty cycle of the echosounder and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of baleen whales, the multibeam echosounder signals (12 kHz) do not overlap with the predominant frequencies in the calls, which would avoid any significant masking.

Behavioral Responses - Behavioral reactions of free-ranging marine mammals to sonars, echosounders, and other sound sources appear to vary by species and circumstance. Observed reactions have included silencing and dispersal by sperm whales (Watkins et al., 1985), increased vocalizations and no dispersal by pilot whales (Rendell and Gordon, 1999), and the previously-mentioned beachings by beaked whales. During exposure to a 21 to 25 kHz "whale-finding" sonar with a source level of 215 dB re 1 µPa, gray whales reacted by orienting slightly away from the source and being deflected from their course by approximately 200 m (656.2 ft) (Frankel, 2005). When a 38 kHz echosounder and a 150 kHz acoustic Doppler current profiler were transmitting during studies in the Eastern Tropical Pacific, baleen whales showed no significant responses, while spotted and spinner dolphins were detected slightly more often and beaked whales less often during visual surveys (Gerrodette and Pettis, 2005).

Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1 second tonal signals at frequencies similar to those that will be emitted by the multibeam echosounder used by SIO, and to shorter broadband pulsed signals. Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure (Schlundt et al., 2000; Finneran et al., 2002; Finneran and Schlundt, 2004). The relevance of those data to free-ranging odontocetes is uncertain, and in any case, the test sounds were quite different in duration as compared with those from a multibeam echosounder.

Hearing Impairment and Other Physical Effects - Given recent stranding events that have been associated with the operation of naval sonar, there is concern that mid-frequency sonar sounds can cause serious impacts to marine mammals (see above). However, the multibeam echosounder proposed for use by SIO is quite different than sonar used for Navy operations. Pulse duration of the multibeam echosounder is very short relative to the naval sonar. Also, at any given location, an individual marine mammal would be in the beam of the multibeam echosounder for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; Navy sonar often uses near-horizontally-directed sound. Those factors would all reduce the sound energy received from the multibeam echosounder rather drastically relative to that from naval sonar.

NMFS believes that the brief exposure of marine mammals to one pulse, or small numbers of signals, from the multibeam echosounder is not likely to result in the harassment of marine mammals.

Sub-bottom Profiler

SIO will also operate a sub-bottom profiler from the source vessel during the proposed survey. Sounds from the sub-bottom profiler are very short pulses, occurring for 1 to 4 ms once every second. Most of the energy in the sound pulses emitted by the sub-bottom profiler is at 3.5 kHz, and the beam is directed downward. The sub-bottom profiler that may be used on the Revelle has a maximum source level of 204 dB re 1 μPa. Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when a bottom profiler emits a pulse is small - even for a sub-bottom profiler more powerful than that that may be on the Revelle. If the animal was in the area, it would have to pass the transducer at close range in order to be subjected to sound levels that could cause TTS.

Masking - Marine mammal communications will not be masked appreciably by the sub-bottom profiler signals given the directionality of the signal and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of most baleen whales, the sub-bottom profiler signals do not overlap with the predominant frequencies in the calls, which would avoid significant masking.

Behavioral Responses - Marine mammal behavioral reactions to other pulsed sound sources are discussed above, and responses to the sub-bottom profiler are likely to be similar to those for other pulsed sources if received at the same levels. However, the pulsed signals from the sub-bottom profiler are considerably weaker than those from the multibeam echosounder. Therefore, behavioral responses are not expected unless marine mammals are very close to the source.

Hearing Impairment and Other Physical Effects - It is unlikely that the sub-bottom profiler produces pulse levels strong enough to cause hearing impairment or other physical injuries even in an animal that is (briefly) in a position near the source. The sub-bottom profiler is usually operated simultaneously with other higher-power acoustic sources, including airguns. Many marine mammals will move away in response to the approaching higher-power sources or the vessel itself before the mammals would be close enough for there to be any possibility of effects from the less intense sounds from the sub-bottom profiler.

Vessel Movement and Collisions

Vessel movement in the vicinity of marine mammals has the potential to result in either a behavioral response or a direct physical interaction. Both scenarios are discussed below in this section.

Behavioral Responses to Vessel Movement – There are limited data concerning marine mammal behavioral responses to vessel traffic and vessel noise, and a lack of consensus among scientists with respect to what these responses mean or whether they result in short-term or long-term adverse effects. In those cases where there is a busy shipping lane or where there is a large amount of vessel traffic, marine mammals (especially low frequency specialists) may experience acoustic masking (Hildebrand, 2005) if they are present in the area (e.g., killer whales in Puget Sound; Foote et al., 2004; Holt et al., 2008). In cases where vessels actively approach marine mammals (e.g., whale watching or dolphin watching boats), scientists have documented that animals exhibit altered behavior such as increased swimming speed, erratic movement, and active avoidance behavior (Bursk, 1983; Acevedo, 1991; Baker and MacGibbon, 1991; Trites and Bain, 2000; Williams et al., 2002; Constantine et al., 2003), reduced blow interval (Ritcher et al., 2003), disruption of normal social behaviors (Lusseau, 2003, 2006), and the shift of behavioral activities which may increase energetic costs (Constantine et al., 2003, 2004). A detailed review of marine mammal reactions to ships and boats is available in Richardson et al., (1995). For each of the marine mammal taxonomy groups, Richardson et al., (1995) provides the following assessment regarding reactions to vessel traffic:

Toothed whales - "In summary, toothed whales sometimes show no avoidance reaction to vessels, or even approach them. However, avoidance can occur, especially in response to vessels of types used to chase or hunt the animals. This may cause temporary displacement, but we know of no clear evidence that toothed whales have abandoned significant parts of their range because of vessel traffic."

Baleen whales - "When baleen whales receive low-level sounds from distant or stationary vessels, the sounds often seem to be ignored. Some whales approach the sources of these sounds. When vessels approach whales slowly and non-aggressively, whales often exhibit slow and inconspicuous avoidance maneuvers. In response to strong or rapidly changing vessel noise, baleen whales often interrupt their normal behavior and swim rapidly away. Avoidance is especially strong when a boat heads directly toward the whale."

Behavioral responses to stimuli are complex and influenced to varying degrees by a number of factors, such as species, behavioral contexts, geographical regions, source characteristics (moving or stationary, speed, direction, etc.), prior experience of the animal and physical status of the animal. For example, studies have shown that beluga whales' reaction varied when exposed to vessel noise and traffic. In some cases, beluga whales exhibited rapid swimming from ice-breaking vessels up to 80 km (43.2 nmi) away and showed changes in surfacing, breathing, diving, and group composition in the Canadian high Arctic where vessel traffic is rare (Finley et al., 1990). In other cases, beluga whales were more tolerant of vessels, but responded differentially to certain vessels and operating characteristics by reducing their calling rates (especially older animals) in the St. Lawrence River where vessel traffic is common (Blane and Jaakson, 1994). In Bristol Bay, Alaska, beluga whales continued to feed when surrounded by fishing vessels and resisted dispersal even when purposefully harassed (Fish and Vania, 1971).

In reviewing more than 25 years of whale observation data, Watkins (1986) concluded that whale reactions to vessel traffic were "modified by their previous experience and current activity: habituation often occurred rapidly, attention to other stimuli or preoccupation with other activities sometimes overcame their interest or wariness of stimuli." Watkins noticed that over the years of exposure to ships in the Cape Cod area, minke whales changed from frequent positive interest (e.g., approaching vessels) to generally uninterested reactions; fin whales changed from mostly negative (e.g., avoidance) to uninterested reactions; fin whales changed from mostly negative (e.g., avoidance) to uninterested reactions; right whales apparently continued the same variety of responses (negative, uninterested, and positive responses) with little change; and humpbacks dramatically changed from mixed responses that were often negative to reactions that were often strongly positive. Watkins (1986) summarized that "whales near shore, even in regions with low vessel traffic, generally have become less wary of boats and their noises, and they have appeared to be less easily disturbed than previously. In particular locations with intense shipping and repeated approaches by boats (such as the whale-watching areas of Stellwagen Bank), more and more whales had positive reactions to familiar vessels, and they also occasionally approached other boats and yachts in the same ways."

Although the radiated sound from the Revelle will be audible to marine mammals over a large distance, it is unlikely that marine mammals will respond behaviorally (in a manner that NMFS would consider harassment under the MMPA) to low-level distant shipping noise as the animals in the area are likely to be habituated to such noises (Nowacek et al., 2004). In light of these facts, NMFS does not expect the Revelle's movements to result in Level B harassment.

Vessel Strike – Ship strikes of cetaceans can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus, 2001; Laist et al., 2001; Vanderlaan and Taggart, 2007).

The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., the sperm whale). In addition, some baleen whales, such as the North Atlantic right whale, seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al., 2004). These species are primarily large, slow moving whales. Smaller marine mammals (e.g., bottlenose dolphin) move quickly through the water column and are often seen riding the bow wave of large ships. Marine mammal responses to vessels may include avoidance and changes in dive pattern (NRC, 2003).

An examination of all known ship strikes from all shipping sources (civilian and military) indicates vessel speed is a principal factor in whether a vessel strike results in death (Knowlton and Kraus, 2001; Laist et al., 2001; Jensen and Silber, 2003; Vanderlaan and Taggart, 2007). In assessing records in which vessel speed was known, Laist et al. (2001) found a direct relationship between the occurrence of a whale strike and the speed of the vessel involved in the collision. The authors concluded that most deaths occurred when a vessel was traveling in excess of 13 kts (24.1 km/hr, 14.9 mph).

SIO's proposed operation of one source vessel for the proposed survey is relatively small in scale compared to the number of commercial ships transiting at higher speeds in the same areas on an annual basis. The probability of vessel and marine mammal interactions occurring during the proposed survey is unlikely due to the Revelle's slow operational speed, which is typically 5 kts. Outside of seismic operations, the Revelle's cruising speed would be approximately 12 to 12.5 kts, which is generally below the speed at which studies have noted reported increases of marine mammal injury or death (Laist et al., 2001).

As a final point, the Revelle has a number of other advantages for avoiding ship strikes as compared to most commercial merchant vessels, including the following: the Revelle's bridge offers good visibility to visually monitor for marine mammal presence; PSOs posted during operations scan the ocean for marine mammals and must report visual alerts of marine mammal presence to crew; and the PSOs receive extensive training that covers the fundamentals of visual observing for marine mammals and information about marine mammals and their identification at sea.

Entanglement

Entanglement can occur if wildlife becomes immobilized in survey lines, cables, nets, or other equipment that is moving through the water column. The proposed seismic survey would require towing approximately a single 600 m cable streamer. This large of an array carries the risk of entanglement for marine mammals. Wildlife, especially slow moving individuals, such as large whales, have a low probability of becoming entangled due to slow speed of the survey vessel and onboard monitoring efforts. In May 2011, there was one recorded entanglement of an olive ridley sea turtle (Lepidochelys olivacea) in the R/V Marcus G. Langseth's barovanes after the conclusion of a seismic survey off Costa Rica. There have been cases of baleen whales, mostly gray whales (Heyning, 1990), becoming entangled in fishing lines. The probability for entanglement of marine mammals is considered not significant because of the vessel speed and the monitoring efforts onboard the survey vessel.

The potential effects to marine mammals described in this section of the document do not take into consideration the proposed monitoring and mitigation measures described later in this document (see the ''Proposed Mitigation'' and ''Proposed Monitoring and Reporting'' sections) which, as noted are designed to effect the least practicable impact on affected marine mammal species and stocks.

Anticipated Effects on Marine Mammal Habitat

The proposed seismic survey is not anticipated to have any permanent impact on habitats used by the marine mammals in the proposed survey area, including the food sources they use (i.e. fish and invertebrates). Additionally, no physical damage to any habitat is anticipated as a result of conducting the proposed seismic survey. While it is anticipated that the specified activity may result in marine mammals avoiding certain areas due to temporary ensonification, this impact to habitat is temporary and was considered in further detail earlier in this document, as behavioral modification. The main impact associated with the proposed activity will be temporarily elevated noise levels and the associated direct effects on marine mammals in any particular area of the approximately 851 km^2 proposed project area, previously discussed in this notice. The next section discusses the potential impacts of anthropogenic sound sources on common marine mammal prey in the proposed survey area (i.e., fish and invertebrates).

Anticipated Effects on Fish

One reason for the adoption of airguns as the standard energy source for marine seismic surveys is that, unlike explosives, they have not been associated with large-scale fish kills. However, existing information on the impacts of seismic surveys on marine fish and invertebrate populations is limited. There are three types of potential effects of exposure to seismic surveys: (1) pathological, (2) physiological, and (3) behavioral. Pathological effects involve lethal and temporary or permanent sub-lethal injury. Physiological effects involve temporary and permanent primary and secondary stress responses, such as changes in levels of enzymes and proteins. Behavioral effects refer to temporary and (if they occur) permanent changes in exhibited behavior (e.g., startle and avoidance behavior). The three categories are interrelated in complex ways. For example, it is possible that certain physiological and behavioral changes could potentially lead to an ultimate pathological effect on individuals (i.e., mortality).

The specific received sound levels at which permanent adverse effects to fish potentially could occur are little studied and largely unknown. Furthermore, the available information on the impacts of seismic surveys on marine fish is from studies of individuals or portions of a population; there have been no studies at the population scale. The studies of individual fish have often been on caged fish that were exposed to airgun pulses in situations not representative of an actual seismic survey. Thus, available information provides limited insight on possible real-world effects at the ocean or population scale. This makes drawing conclusions about impacts on fish problematic because, ultimately, the most important issues concern effects on marine fish populations, their viability, and their availability to fisheries.

Hastings and Popper (2005), Popper (2009), and Popper and Hastings (2009a,b) provided recent critical reviews of the known effects of sound on fish. The following sections provide a general synopsis of the available information on the effects of exposure to seismic and other anthropogenic sound as relevant to fish. The information comprises results from scientific studies of varying degrees of rigor plus some anecdotal information. Some of the data sources may have serious shortcomings in methods, analysis, interpretation, and reproducibility that must be considered when interpreting their results (see Hastings and Popper, 2005). Potential adverse effects of the program's sound sources on marine fish are noted.

Pathological Effects – The potential for pathological damage to hearing structures in fish depends on the energy level of the received sound and the physiology and hearing capability of the species in question. For a given sound to result in hearing loss, the sound must exceed, by some substantial amount, the hearing threshold of the fish for that sound (Popper, 2005). The consequences of temporary or permanent hearing loss in individual fish on a fish population are unknown; however, they likely depend on the number of individuals affected and whether critical behaviors involving sound (e.g., predator avoidance, prey capture, orientation and navigation, reproduction, etc.) are adversely affected.

Little is known about the mechanisms and characteristics of damage to fish that may be inflicted by exposure to seismic survey sounds. Few data have been presented in the peer-reviewed scientific literature. As far as SIO and NMFS know, there are only two papers with proper experimental methods, controls, and careful pathological investigation implicating sounds produced by actual seismic survey airguns in causing adverse anatomical effects. One such study indicated anatomical damage, and the second indicated TTS in fish hearing. The anatomical case is McCauley et al. (2003), who found that exposure to airgun sound caused observable anatomical damage to the auditory maculae of pink snapper (Pagrus auratus). This damage in the ears had not been repaired in fish sacrificed and examined almost two months after exposure. On the other hand, Popper et al. (2005) documented only TTS (as determined by auditory brainstem response) in two of three fish species from the Mackenzie River Delta. This study found that broad whitefish (Coregonus nasus) exposed to five airgun shots were not significantly different from those of controls. During both studies, the repetitive exposure to sound was greater than would have occurred during a typical seismic survey. However, the substantial low-frequency energy produced by the airguns (less than 400 Hz in the study by McCauley et al. [2003] and less than approximately 200 Hz in Popper et al. [2005]) likely did not propagate to the fish because the water in the study areas was very shallow (approximately nine m in the former case and less than two m in the latter). Water depth sets a lower limit on the lowest sound frequency that will propagate (the "cutoff frequency") at about one-quarter wavelength (Urick, 1983; Rogers and Cox, 1988).

Wardle et al. (2001) suggested that in water, acute injury and death of organisms exposed to seismic energy depends primarily on two features of the sound source: (1) the received peak pressure, and (2) the time required for the pressure to rise and decay. Generally, as received pressure increases, the period for the pressure to rise and decay decreases, and the chance of acute pathological effects increases. According to Buchanan et al. (2004), for the types of seismic airguns and arrays involved with the proposed program, the pathological (mortality) zone for fish would be expected to be within a few meters of the seismic source. Numerous other studies provide examples of no fish mortality upon exposure to seismic sources (Falk and Lawrence, 1973; Holliday et al., 1987; La Bella et al., 1996; Santulli et al., 1999; McCauley et al., 2000a,b, 2003; Bjarti, 2002; Thomsen, 2002; Hassel et al., 2003; Popper et al., 2005; Boeger et al., 2006).

An experiment of the effects of a single 700 in^3 airgun was conducted in Lake Meade, Nevada (USGS, 1999). The data were used in an Environmental Assessment of the effects of a marine reflection survey of the Lake Meade fault system by the National Park Service (Paulson et al., 1993, in USGS, 1999). The airgun was suspended 3.5 m (11.5 ft) above a school of threadfin shad in Lake Meade and was fired three successive times at a 30 second interval. Neither surface inspection nor diver observations of the water column and bottom found any dead fish.

For a proposed seismic survey in Southern California, USGS (1999) conducted a review of the literature on the effects of airguns on fish and fisheries. They reported a 1991 study of the Bay Area Fault system from the continental shelf to the Sacramento River, using a 10 airgun (5,828 in^3) array. Brezzina and Associates were hired by USGS to monitor the effects of the surveys and concluded that airgun operations were not responsible for the death of any of the fish carcasses observed. They also concluded that the airgun profiling did not appear to alter the feeding behavior of sea lions, seals, or pelicans observed feeding during the seismic surveys.

Some studies have reported, some equivocally, that mortality of fish, fish eggs, or larvae can occur close to seismic sources (Kostyuchenko, 1973; Dalen and Knutsen, 1986; Booman et al., 1996; Dalen et al., 1996). Some of the reports claimed seismic effects from treatments quite different from actual seismic survey sounds or even reasonable surrogates. However, Payne et al. (2009) reported no statistical differences in mortality/morbidity between control and exposed groups of capelin eggs or monkfish larvae. Saetre and Ona (1996) applied a 'worst-case scenario' mathematical model to investigate the effects of seismic energy on fish eggs and larvae. They concluded that mortality rates caused by exposure to seismic surveys are so low, as compared to natural mortality rates, that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

Physiological Effects - Physiological effects refer to cellular and/or biochemical responses of fish to acoustic stress. Such stress potentially could affect fish populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses of fish after exposure to seismic survey sound appear to be temporary in all studies done to date (Sverdrup et al., 1994; Santulli et al., 1999; McCauley et al., 2000a,b). The periods necessary for the biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus.

Behavioral Effects - Behavioral effects include changes in the distribution, migration, mating, and catchability of fish populations. Studies investigating the possible effects of sound (including seismic survey sound) on fish behavior have been conducted on both uncaged and caged individuals (e.g., Chapman and Hawkins, 1969; Pearson et al., 1992; Santulli et al., 1999; Wardle et al., 2001; Hassel et al., 2003). Typically, in these studies fish exhibited a sharp startle response at the onset of a sound followed by habituation and a return to normal behavior after the sound ceased.

The Minerals Management Service (MMS, 2005) assessed the effects of a proposed seismic survey in Cook Inlet. The seismic survey proposed using three vessels, each towing two, four-airgun arrays ranging from 1,500 to 2,500 in^3. MMS noted that the impact to fish populations in the survey area and adjacent waters would likely be very low and temporary. MMS also concluded that seismic surveys may displace the pelagic fishes from the area temporarily when airguns are in use. However, fishes displaced and avoiding the airgun noise are likely to backfill the survey area in minutes to hours after cessation of seismic testing. Fishes not dispersing from the airgun noise (e.g., demersal species) may startle and move short distances to avoid airgun emissions.

In general, any adverse effects on fish behavior or fisheries attributable to seismic testing may depend on the species in question and the nature of the fishery (season, duration, fishing method). They may also depend on the age of the fish, its motivational state, its size, and numerous other factors that are difficult, if not impossible, to quantify at this point, given such limited data on effects of airguns on fish, particularly under realistic at-sea conditions.

Anticipated Effects on Invertebrates

The existing body of information on the impacts of seismic survey sound on marine invertebrates is very limited. However, there is some unpublished and very limited evidence of the potential for adverse effects on invertebrates, thereby justifying further discussion and analysis of this issue. The three types of potential effects of exposure to seismic surveys on marine invertebrates are pathological, physiological, and behavioral. Based on the physical structure of their sensory organs, marine invertebrates appear to be specialized to respond to particle displacement components of an impinging sound field and not to the pressure component (Popper et al., 2001).

The only information available on the impacts of seismic surveys on marine invertebrates involves studies of individuals; there have been no studies at the population scale. Thus, available information provides limited insight on possible real-world effects at the regional or ocean scale. The most important aspect of potential impacts concerns how exposure to seismic survey sound ultimately affects invertebrate populations and their viability, including availability to fisheries.

Literature reviews of the effects of seismic and other underwater sound on invertebrates were provided by Moriyasu et al. (2004) and Payne et al. (2008). The following sections provide a synopsis of available information on the effects of exposure to seismic survey sound on species of decapod crustaceans and cephalopods, the two taxonomic groups of invertebrates on which most such studies have been conducted. The available information is from studies with variable degrees of scientific soundness and from anecdotal information. A more detailed review of the literature on the effects of seismic survey sound on invertebrates is provided in Appendix D of NSF/USGS's PEIS.

Pathological Effects – In water, lethal and sub-lethal injury to organisms exposed to seismic survey sound appears to depend on at least two features of the sound source: (1) the received peak pressure; and (2) the time required for the pressure to rise and decay. Generally, as received pressure increases, the period for the pressure to rise and decay decreases, and the chance of acute pathological effects increases. For the type of airgun array planned for the proposed program, the pathological (mortality) zone for crustaceans and cephalopods is expected to be within a few meters of the seismic source, at most; however, very few specific data are available on levels of seismic signals that might damage these animals. This premise is based on the peak pressure and rise/decay time characteristics of seismic airgun arrays currently in use around the world.

Some studies have suggested that seismic survey sound has a limited pathological impact on early developmental stages of crustaceans (Pearson et al., 1994; Christian et al., 2003; DFO, 2004). However, the impacts appear to be either temporary or insignificant compared to what occurs under natural conditions. Controlled field experiments on adult crustaceans (Christian et al., 2003, 2004; DFO, 2004) and adult cephalopods (McCauley et al., 2000a,b) exposed to seismic survey sound have not resulted in any significant pathological impacts on the animals. It has been suggested that exposure to commercial seismic survey activities has injured giant squid (Guerra et al., 2004), but the article provides little evidence to support this claim. Tenera Environmental (2011b) reported that Norris and Mohl (1983, summarized in Mariyasu et al., 2004) observed lethal effects in squid (Loligo vulgaris) at levels of 246 to 252 dB after 3 to 11 minutes.

Andre et al. (2011) exposed four species of cephalopods (Loligo vulgaris, Sepia officinalis, Octopus vulgaris, and Ilex coindetii), primarily cuttlefish, to two hours of continuous 50 to 400 Hz sinusoidal wave sweeps at 157+/-5 dB re 1 µPa while captive in relatively small tanks. They reported morphological and ultrastructural evidence of massive acoustic trauma (i.e., permanent and substantial alterations [lesions] of statocyst sensory hair cells) to the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low frequency sound. The received SPL was reported as 157+/-5 dB re 1 µPa, with peak levels at 175 dB re 1 µPa. As in the McCauley et al. (2003) paper on sensory hair cell damage in pink snapper as a result of exposure to seismic sound, the cephalopods were subjected to higher sound levels than they would be under natural conditions, and they were unable to swim away from the sound source.

Physiological Effects - Physiological effects refer mainly to biochemical responses by marine invertebrates to acoustic stress. Such stress potentially could affect invertebrate populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses (i.e., changes in haemolymph levels of enzymes, proteins, etc.) of crustaceans have been noted several days or months after exposure to seismic survey sounds (Payne et al., 2007). It was noted however, than no behavioral impacts were exhibited by crustaceans (Christian et al., 2003, 2004; DFO, 2004). The periods necessary for these biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus.

Behavioral Effects – There is increasing interest in assessing the possible direct and indirect effects of seismic and other sounds on invertebrate behavior, particularly in relation to the consequences for fisheries. Changes in behavior could potentially affect such aspects as reproductive success, distribution, susceptibility to predation, and catchability by fisheries. Studies investigating the possible behavioral effects of exposure to seismic survey sound on crustaceans and cephalopods have been conducted on both uncaged and caged animals. In some cases, invertebrates exhibited startle responses (e.g., squid in McCauley et al., 2000a,b). In other cases, no behavioral impacts were noted (e.g., crustaceans in Christian et al., 2003, 2004; DFO 2004). There have been anecdotal reports of reduced catch rates of shrimp shortly after exposure to seismic surveys; however, other studies have not observed any significant changes in shrimp catch rate (Andriguetto-Filho et al., 2005). Similarly, Parry and Gason (2006) did not find any evidence that lobster catch rates were affected by seismic surveys. Any adverse effects on crustacean and cephalopod behavior or fisheries attributable to seismic survey sound depend on the species in question and the nature of the fishery (season, duration, fishing method).

Proposed Mitigation

In order to issue an Incidental Take Authorization (ITA) under section 101(a)(5)(D) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and the availability of such species or stock for taking for certain subsistence uses.

SIO reviewed the following source documents and have incorporated a suite of appropriate mitigation measures into their project description.

(1) Protocols used during previous NSF and USGS-funded seismic research cruises as approved by NMFS and detailed in the recently completed "Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey;"

(2) Previous IHA applications and IHAs approved and authorized by NMFS; and

(3) Recommended best practices in Richardson et al. (1995), Pierson et al. (1998), and Weir and Dolman, (2007).

To reduce the potential for disturbance from acoustic stimuli associated with the activities, SIO and/or its designees have proposed to implement the following mitigation measures for marine mammals:

(1) Proposed exclusion zones around the sound source;

(2) Speed and course alterations;

(3) Shut-down procedures; and

(4) Ramp-up procedures.

Proposed Exclusion Zones – SIO use radii to designate exclusion and buffer zones and to estimate take for marine mammals. Table 2 (presented earlier in this document) shows the distances at which one would expect to receive three sound levels (160, 180, and 190 dB) from the two GI airgun array. The 180 dB level shut-down criteria are applicable to cetaceans, as specified by NMFS (2000). SIO used these levels to establish the exclusion and buffer zones.

Received sound levels have been modeled by L-DEO for a number of airgun configurations, including two 45 in^3 Nucleus G airguns, in relation to distance and direction from the airguns (see Figure 2 of the IHA application). In addition, propagation measurements of pulses from two GI airguns have been reported for shallow water (approximately 30 m [98.4 ft] depth in the GOM (Tolstoy et al., 2004). However, measurements were not made for the two GI airguns in deep water. The model does not allow for bottom interactions, and is most directly applicable to deep water. Based on the modeling, estimates of the maximum distances from the GI airguns where sound levels are predicted to be 180 and 160 dB re 1 μPa (rms) in deep water were determined (see Table 2 above).

Empirical data concerning the 180 and 160 dB (rms) distances were acquired for various airgun arrays based on measurements during the acoustic verification studies conducted by L-DEO in the northern GOM in 2003 (Tolstoy et al., 2004) and 2007 to 2008 (Tolstoy et al., 2009). Results of the 36 airgun array are not relevant for the two GI airguns to be used in the proposed survey. The empirical data for the 6, 10, 12, and 20 airgun arrays indicate that, for deep water, the L-DEO model tends to overestimate the received sound levels at a given distance (Tolstoy et al., 2004). Measurements were not made for the two GI airgun array in deep water; however, SIO propose to use the safety radii predicted by L-DEO's model for the proposed GI airgun operations in deep water, although they are likely conservative given the empirical results for the other arrays. The 180 dB (rms) radii are shut-down criteria applicable to cetaceans and pinnipeds, respectively, as specified by NMFS (2000); these levels were used to establish exclusion zones. Therefore, the assumed 180 dB radii are 100 m for intermediate and deep water, respectively. If the PSO detects a marine mammal(s) within or about to enter the appropriate exclusion zone, the airguns will be shut-down immediately.

Speed and Course Alterations – If a marine mammal is detected outside the exclusion zone and, based on its position and direction of travel (relative motion), is likely to enter the exclusion zone, changes of the vessel's speed and/or direct course will be considered if this does not compromise operational safety. This would be done if operationally practicable while minimizing the effect on the planned science objectives. For marine seismic surveys towing large streamer arrays, however, course alterations are not typically implemented due to the vessel's limited maneuverability. After any such speed and/or course alteration is begun, the marine mammal activities and movements relative to the seismic vessel will be closely monitored to ensure that the marine mammal does not approach within the exclusion zone. If the marine mammal appears likely to enter the exclusion zone, further mitigation actions will be taken, including further course alterations and/or shut-down of the airgun(s). Typically, during seismic operations, the source vessel is unable to change speed or course, and one or more alternative mitigation measures will need to be implemented.

Shut-down Procedures - SIO will shut-down the operating airgun(s) if a marine mammal is detected outside the exclusion zone for the airgun(s), and if the vessel's speed and/or course cannot be changed to avoid having the animal enter the exclusion zone, the seismic source will be shut-down before the animal is within the exclusion zone. Likewise, if a marine mammal is already within the exclusion zone when first detected, the seismic source will be shut down immediately.

Following a shut-down, SIO will not resume airgun activity until the marine mammal has cleared the exclusion zone. SIO will consider the animal to have cleared the exclusion zone if:

- A PSO has visually observed the animal leave the exclusion zone, or
- A PSO has not sighted the animal within the exclusion zone for 15 minutes for species with shorter dive durations (i.e., small odontocetes), or 30 minutes for species with longer dive durations (i.e., mysticetes and large odontocetes, including sperm, pygmy and dwarf sperm, killer, and beaked whales).

Although power-down procedures are often standard operating practice for seismic surveys, they are not proposed to be used during this planned seismic survey because powering-down from two airguns to one airgun would make only a small difference in the exclusion zone(s) – but probably not enough to allow continued one-airgun operations if a marine mammal came within the exclusion zone for two airguns.

Ramp-up Procedures – Ramp-up of an airgun array provides a gradual increase in sound levels, and involves a step-wise increase in the number and total volume of airguns firing until the full volume of the airgun array is achieved. The purpose of a ramp-up is to "warn" marine mammals in the vicinity of the airguns and to provide the time for them to leave the area avoiding any potential injury or impairment of their hearing abilities. SIO will follow a ramp-up procedure when the airgun array begins operating after a specified period without airgun operations or when a shut-down shut down has exceeded that period. SIO proposes that, for the present cruise, this period would be approximately 15 minutes. L-DEO and USGS has used similar periods (approximately 15 minutes) during previous low-energy seismic surveys.

Ramp-up will begin with a single GI airgun (45 in^3). The second GI airgun (45 in^3) will be added after 5 minutes. During ramp-up, the PSOs will monitor the exclusion zone, and if marine mammals are sighted, a shut-down will be implemented as though both GI airguns were operational.

If the complete exclusion zone has not been visible for at least 30 minutes prior to the start of operations in either daylight or nighttime, SIO will not commence the ramp-up. Given these provisions, it is likely that the airgun array will not be ramped-up from a complete shut-down at night or in thick fog, because the outer part of the exclusion zone for that array will not be visible during those conditions. If one airgun has operated, ramp-up to full power will be permissible at night or in poor visibility, on the assumption that marine mammals will be alerted to the approaching seismic vessel by the sounds from the single airgun and could move away if they choose. A ramp-up from a shut-down may occur at night, but only where the exclusion zone is small enough to be visible. SIO will not initiate a ramp-up of the airguns if a marine mammal is sighted within or near the applicable exclusion zones during the day or close to the vessel at night.

NMFS has carefully evaluated the applicant's proposed mitigation measures and has considered a range of other measures in the context of ensuring that NMFS prescribes the means of effecting the least practicable adverse impact on the affected marine mammal species and stocks and their habitat. NMFS's evaluation of potential measures included consideration of the following factors in relation to one another:

(1) The manner in which, and the degree to which, the successful implementation of the measure is expected to minimize adverse impacts to marine mammals;

(2) The proven or likely efficacy of the specific measure to minimize adverse impacts as planned; and

(3) The practicability of the measure for applicant implementation.

Based on NMFS's evaluation of the applicant's proposed measures, as well as other measures considered by NMFS or recommended by the public, NMFS has preliminarily determined that the proposed mitigation measures provide the means of effecting the least practicable adverse impacts on marine mammal species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Proposed Monitoring and Reporting

In order to issue an ITA for an activity, section 101(a)(5)(D) of the MMPA states that NMFS must set forth "requirements pertaining to the monitoring and reporting of such taking." The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for IHAs must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the action area.

Proposed Monitoring

SIO proposes to sponsor marine mammal monitoring during the proposed project, in order to implement the proposed mitigation measures that require real-time monitoring, and to satisfy the anticipated monitoring requirements of the IHA. SIO's proposed "Monitoring Plan" is described below this section. SIO understand that this monitoring plan will be subject to review by NMFS and that refinements may be required. The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same regions. SIO is prepared to discuss coordination of their monitoring program with any related work that might be done by other groups insofar as this is practical and desirable.

Vessel-based Visual Monitoring

PSOs will be based aboard the seismic source vessel and will watch for marine mammals near the vessel during daytime airgun operations and during any ramp-ups of the airguns at night. PSOs will also watch for marine mammals near the seismic vessel for at least 30 minutes prior to the start of airgun operations after an extended shut-down (i.e., greater than approximately 15 minutes for this proposed cruise). When feasible, PSOs will conduct observations during daytime periods when the seismic system is not operating for comparison of sighting rates and behavior with and without airgun operations and between acquisition periods. Based on PSO observations, the airguns will be shut-down when marine mammals are observed within or about to enter a designated exclusion zone. The exclusion zone is a region in which a possibility exists of adverse effects on animal hearing or other physical effects.

During seismic operations in the tropical western Pacific Ocean, at least three PSOs will be based aboard the Revelle. SIO will appoint the PSOs with NMFS's concurrence. Observations will take place during ongoing daytime operations and nighttime ramp-ups of the airguns. During the majority of seismic operations, at least one PSO will be on duty from observation platforms (i.e., the best available vantage point on the source vessel) to monitor marine mammals near the seismic vessel. PSO(s) will be on duty in shifts no longer than 4 hours in duration. Other crew will also be instructed to assist in detecting marine mammals and implementing mitigation requirements (if practical). Before the start of the seismic survey, the crew will be given additional instruction on how to do so.

The Revelle is a suitable platform for marine mammal observations and will serve as the platform from which PSOs will watch for marine mammals before and during seismic operations. The Revelle has been used for that purpose during the routine California Cooperative Oceanic Fisheries Investigations (CalCOFI). Two locations are likely as observation stations onboard the Revelle. Observing stations are located on the 02 level, with the PSO eye level at approximately 10.4 m (34.1 ft) above the waterline. At a forwarded-centered position on the 02 deck, the view is approximately 240º; an aft-centered view includes the 100 m (328.1 ft) radius area around the GI airguns. The PSO eye level on the bridge is approximately 15 m (49.2 ft) above sea level. Standard equipment for PSOs will be reticule binoculars and optical range finders. At night, night-vision equipment will be available. The PSOs will be in communication with ship's officers on the bridge and scientists in the vessel's operations laboratory, so they can advise promptly of the need for avoidance maneuvers or seismic source shut-down. Observing stations will be at the 02 level with PSO's eye level approximately 10.4 m (34 ft) above sea level – one forward on the 02 deck commanding a forward-centered, approximately 240º view around the vessel, and one atop the aft hangar, with an aft-centered view that includes the radii around the airguns. The eyes on the bridge watch will be at a height of approximately 15 m (49 ft); PSOs will work on the enclosed bridge and adjoining aft steering station during any inclement weather. During daytime, the PSO(s) will scan the area around the vessel systematically with reticle binoculars (e.g., 7 x 50 Fujinon), Big-eye binoculars (e.g., 25 x 150), optical range-finders (to assist with distance estimation), and the naked eye. At night, night-vision equipment will be available. The optical range-finders are useful in training observers to estimate distances visually, but are generally not useful in measuring distances to animals directly. Estimating distances is done primarily with the reticles in the binoculars. The PSO(s) will be in wireless communication with ship's officers on the bridge and scientists in the vessel's operations laboratory, so they can advise promptly of the need for avoidance maneuvers or a shut-down of the seismic source.

When marine mammals are detected within or about to enter the designated exclusion zone, the airguns will immediately be shut-down if necessary. The PSO(s) will continue to maintain watch to determine when the animal(s) are outside the exclusion zone by visual confirmation. Airgun operations will not resume until the animal is confirmed to have left the exclusion zone, or if not observed after 15 minutes for species with shorter dive durations (small odontocetes) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales).

PSO Data and Documentation

PSOs will record data to estimate the numbers of marine mammals exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. Data will be used to estimate numbers of animals potentially "taken" by harassment (as defined in the MMPA). They will also provide information needed to order a shut-down of the airguns when a marine mammal is within or near the exclusion zone. Observations will also be made during daytime periods when the Revelle is underway without seismic operations (i.e., transits, to, from, and through the study area) to collect baseline biological data.

When a sighting is made, the following information about the sighting will be recorded:

1. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the seismic source or vessel (e.g., none, avoidance, approach, paralleling, etc.), and behavioral pace.

2. Time, location, heading, speed, activity of the vessel, sea state, wind force, visibility, and sun glare.

The data listed under (2) will also be recorded at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

All observations, as well as information regarding ramp-ups or shut-downs will be recorded in a standardized format. Data will be entered into an electronic database. The data accuracy will be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database by the PSOs at sea. These procedures will allow initial summaries of data to be prepared during and shortly after the field program, and will facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

Results from the vessel-based observations will provide the following information:

1. The basis for real-time mitigation (airgun shut-down).

2. Information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS.

3. Data on the occurrence, distribution, and activities of marine mammals in the area where the seismic study is conducted.

4. Information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity.

5. Data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity.

SIO will submit a comprehensive report to NMFS within 90 days after the end of the cruise. The report will describe the operations that were conducted and sightings of marine mammals near the operations. The report submitted to NMFS will provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report will summarize the dates and locations of seismic operations and all marine mammal sightings (i.e., dates, times, locations, activities, and associated seismic survey activities). The report will minimally include:

- Summaries of monitoring effort – total hours, total distances, and distribution of marine mammals through the study period accounting for sea state and other factors affecting visibility and detectability of marine mammals;
- Analyses of the effects of various factors influencing detectability of marine mammals including sea state, number of PSOs, and fog/glare;
- Species composition, occurrence, and distribution of marine mammals sightings including date, water depth, numbers, age/size/gender, and group sizes; and analyses of the effects of seismic operations;
- Sighting rates of marine mammals during periods with and without airgun activities (and other variables that could affect detectability);
- Initial sighting distances versus airgun activity state;
- Closest point of approach versus airgun activity state;
- Observed behaviors and types of movements versus airgun activity state;
- Numbers of sightings/individuals seen versus airgun activity state; and
- Distribution around the source vessel versus airgun activity state.

The report will also include estimates of the number and nature of exposures that could result in "takes" of marine mammals by harassment or in other ways. After the report is considered final, it will be publicly available on the NMFS website at: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha.

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this IHA, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), SIO will immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and Howard.Goldstein@noaa.gov, and the NMFS Pacific Islands Region Marine Mammal Stranding and Entanglement Hotline at 1-888-256-9840 (David.Schofield@noaa.gov). The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with SIO to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS via letter or email, or telephone.

In the event that SIO discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), SIO will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov and Howard.Goldstein@noaa.gov, and the NMFS Pacific Islands Region Marine Mammal Stranding and Entanglement Hotline (1-888-256-9840) and/or by email to the Pacific Islands Regional Stranding Coordinator (David.Schofield@noaa.gov). The report must include the same information identified in the paragraph above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether modifications in the activities are appropriate.

In the event that SIO discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate or advanced decomposition, or scavenger damage), SIO will report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov and Howard.Goldstein@noaa.gov, and the NMFS Pacific Islands Regional Marine Mammal Stranding and Entanglement Hotline (1-888-256-9840), and/or by email to the Pacific Islands Regional Stranding Coordinator (David.Schofield@noaa.gov), within

24 hours of discovery. SIO will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

Estimated Take by Incidental Harassment

Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment].

Level B harassment is anticipated and proposed to be authorized as a result of the proposed low-energy marine seismic survey in the tropical western Pacific Ocean. Acoustic stimuli (i.e., increased underwater sound) generated during the operation of the seismic airgun array are expected to result in the behavioral disturbance of some marine mammals. There is no evidence that the planned activities could result in injury, serious injury, or mortality for which SIO seeks the IHA. The required mitigation and monitoring measures will minimize any potential risk for injury, serious injury, or mortality.

The following sections describe SIO’s methods to estimate take by incidental harassment and present the applicant’s estimates of the numbers of marine mammals that could be affected during the proposed seismic program in the tropical western Pacific Ocean. The estimates are based on a consideration of the number of marine mammals that could be harassed by approximately 1,033 km (557.8 nmi) of seismic operations with the two GI airgun array to be used as depicted in Figure 1 of the IHA application.

SIO assumes that, during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the multibeam echosounder and sub-bottom profiler would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, marine mammals are expected to exhibit no more than short-term and inconsequential responses to the multibeam echosounder and sub-bottom profiler given their characteristics (e.g., narrow, downward-directed beam) and other considerations described previously. Such reactions are not considered to constitute "taking" (NMFS, 2001). Therefore, SIO provides no additional allowance for animals that could be affected by sound sources other than airguns.

The only densities reported for the overall proposed survey area are for eight species sighted during vessel-based surveys in coastal and oceanic waters of the Sulu Sea, Philippines, covering an area of approximately 23,000 km^2 (6,705.7 nmi^2), during May to June 1994 and 1995 (Dolar et al., 2006). To supplement those density data, SIO used densities for seven other species expected to occur in the proposed survey area that were sighted during a systematic vessel-based marine mammal survey in Guam and the southern Commonwealth of the Northern Mariana Islands (CNMI) during January to April 2007 (Fulling et al., 2011). The cruise area was defined by the boundaries 10 to 18º North and 142 to 148º East, encompassing an area of approximately 585,000 km^2 (170,558.7 nmi^2). For five species not sighted in either survey, but expected to occur in the proposed survey area, SIO also used densities for the "outer EEZ stratum" of Hawaiian waters, covering approximately 2,240,000 km^2 (653,079.5 nmi^2), based on a survey conducted in August to November 2002 (Barlow, 2006). All three surveys used standard line-transect protocols developed by NMFS Southwest Fisheries Science Center.

Survey effort was 2,313 km (1,248.9 nmi) in the Sulu Sea, 11,033 km (5,957.3 nmi) in the CNMI, and 13,500 km (7,289.4 nmi) in Hawaii.

The densities mentioned above have been corrected, by the original authors, for trackline detection probability bias, and in one of the three areas, for availability bias. Trackline detection probability bias is associated with diminishing sightability with increasing lateral distance from the trackline f(0). Availability bias refers to the fact that there is less than 100% probability of sighting an animal that is present along the survey trackline, and it is measured by g(0). Dolar et al. (2006) and Fulling et al. (2011) did not correct the CNMI densities for g(0), which for all but large (greater than 20) groups of dolphins (where g(0) = 1), resulted in underestimates of density. Although there is some uncertainty about the representatives of the data and the assumptions used in the calculations below, the approach used here is believed to be the best available approach.

Table 4. Estimated densities and possible number of marine mammal species that might be exposed to greater than or equal to 160 dB during SIO's proposed seismic survey (ensonified area 1,063.8 km^2) in the tropical western Pacific Ocean, September to October 2013.

Species	Density (#/1,000 km^2)[1,2]	Calculated Take (i.e., Estimated Number of Individuals Exposed to Sound Levels ≥ 160 dB re 1 μPa)[3]	Approximate Percentage of Best Population Estimate of Stock (Calculated Take)[4]	Requested Take Authorization[5]
Mysticetes				
Humpback whale	NA	0	0.03	1
Minke whale	NA	0	0.01	3
Bryde's whale	0.41	0	0.01	2
Omura's whale	NA	0	NA	2
Sei whale	0.29	0	0.03 to 0.02	2
Fin whale	NA	0	0.05 to 0.04	7
Blue whale	NA	0	NA	2
Odontocetes				
Sperm whale	1.23	1	0.02 (<0.01)	5
Pygmy sperm whale	3.19	3	NA (NA)	3
Dwarf sperm whale	5	5	0.05 (0.05)	5
Cuvier's beaked whale	6.8	7	0.04 (0.04)	7
Longman's beaked whale	0.45	0	NA (NA)	18
Ginkgo-toothed beaked whale	0	0	<0.01 (0)	2
Blainville's beaked whale	1.28	1	<0.01 (<0.01)	2
Killer whale	0.16	0	0.08	7
Short-finned pilot whale	160.0	170	0.32 (0.32)	170
False killer whale	1.11	1	0.06 (<0.01)	10

Melon-headed whale	20.0	21	0.07 (0.05)	31
Pygmy killer whale	0.14	0	0.02 (0)	6
Risso’s dolphin	15.0	16	0.02 (0.02)	16
Bottlenose dolphin	55.0	59	0.04 (0.04)	59
Rough-toothed dolphin	0.29	0	0.01 (0)	9
Fraser’s dolphin	215.0	229	0.08 (0.08)	229
Striped dolphin	6.16	7	<0.01 (<0.01)	27
Pantropical spotted dolphin	325.0	346	0.08 (0.08)	346
Spinner dolphin	685.0	729	0.1 (0.1)	729

NA = Not available or not assessed.

[1] Densities calculated from Table 4 of Barlow (2006) using the abundance in the outer EEZ stratum and the surface area of the stratum give on p. 452 of Barlow (2006).

[2] A correction factor of 0.5 was applied to the densities of Dolar et al. (2006) because those densities were from surveys that included coastal waters, and approximately 50% of the total ensonified area for the proposed survey is in deep water, far offshore, where marine mammal densities are expected to be lower; see densities in Fulling et al. (2011) and Barlow (2006).

[3] Calculated take is estimated density (reported density times correction factor) multiplied by the area ensonified to 160 dB (rms) around the planned seismic lines, increased by 25% for contingency.

[4] Requested (and calculated) takes expressed as percentages of the regional populations.

[5] Requested Take Authorization increased to mean group size for species for which densities were not available but that have been sighted in the proposed survey area and for species whose calculated takes were less than group size.

SIO estimated the number of different individuals that may be exposed to airgun sounds with received levels greater than or equal to 160 dB re 1 μPa (rms) on one or more occasions by considering the total marine area that would be within the 160 dB radius around the operating airgun array on at least one occasion and the expected density of marine mammals in the area (in the absence of the a seismic survey). The number of possible exposures (including repeat exposures of the same individuals) can be estimated by considering the total marine area that would be within the 160 dB radius around the operating airguns, excluding areas of overlap. During the proposed survey, the transect lines are widely spaced relative to the 160 dB (rms) distance (600 m for intermediate water depths and 400 m for deep water depths). Thus, the area including overlap is 1.07 times the area excluding overlap, so a marine mammal that stayed in the survey areas during the entire survey could be exposed slightly more than once, on average. However, it is unlikely that a particular animal would stay in the area during the entire survey.

The number of different individuals potentially exposed to received levels greater than or equal to 160 re 1 μPa (rms) was calculated by multiplying:

(1) The expected species density (in number/km^2), times

(2) The anticipated area to be ensonified to that level during airgun operations excluding overlap.

The area expected to be ensonified was determined by entering the planned survey lines into a MapInfo GIS, using the GIS to identify the relevant areas by "drawing" the applicable 160 dB buffer (see Table 1 of the IHA application) around each seismic line, and then calculating the total area within the buffers.

Applying the approach described above, approximately 851 km^2 (approximately 1,063.8 km^2 including the 25% contingency) would be within the 160 dB isopleth on one or more occasions during the proposed survey. The take calculations within the study sites do not explicitly add animals to account for the fact that new animals (i.e., turnover) are not accounted for in the initial density snapshot and animals could also approach and enter the area ensonified above 160 dB; however, studies suggest that many marine mammals will avoid exposing themselves to sounds at this level, which suggests that there would not necessarily be a large number of new animals entering the area once the seismic survey started. Because this approach for calculating take estimates does not allow for turnover in the marine mammal populations in the area during the course of the survey, the actual number of individuals exposed may be underestimated, although the conservative (i.e., probably overestimated) line-kilometer distances used to calculate the area may offset this. Also, the approach assumes that no cetaceans will move away or toward the tracklines as the Revelle approaches in response to increasing sound levels before the levels reach 160 dB. Another way of interpreting the estimates that follow is that they represent the number of individuals that are expected (in absence of a seismic program) to occur in the waters that will be exposed to greater than or equal to 160 dB (rms).

SIO's estimates of exposures to various sound levels assume that the proposed surveys will be carried out in full; however, the ensonified areas calculated using the planned number of line-kilometers has been increased by 25% to accommodate lines that may need to be repeated, equipment testing, etc. As is typical during offshore ship surveys, inclement weather and equipment malfunctions are likely to cause delays and may limit the number of useful line-kilometers of seismic operations that can be undertaken. The estimates of the numbers of marine mammals potentially exposed to 160 dB (rms) received levels are precautionary and probably overestimate the actual numbers of marine mammals that could be involved. These estimates assume that there will be no weather, equipment, or mitigation delays, which is highly unlikely.

Table 4 (Table 4 of the IHA application) shows the estimates of the number of different individual marine mammals anticipated to be exposed to greater than or equal to 160 dB re 1 μPa (rms) during the seismic survey if no animals moved away from the survey vessel. The requested take authorization is given in the far right column of Table 4 (Table 4 of the IHA application). The requested take authorization has been increased to the average mean group sizes from the surveys whose densities were used in the calculations, or from Jefferson et al. (2008) for species not sighted during the surveys.

The estimate of the number of individual cetaceans that could be exposed to seismic sounds with received levels greater than or equal to 160 dB re 1 μPa (rms) during the proposed survey is (with 25% contingency) in Table 4 of this document (see Table 4 of the IHA application). That total (with 25% contingency) includes 0 baleen whales, 1 sperm whale, 3 pygmy sperm whales, 5 dwarf sperm whale, 7 Cuvier's beaked whales, and 1 Blainville's beaked whales could be taken by Level B harassment during the proposed seismic survey, which would represent 0, <0.01, NA, 0.05, 0.04, 0.01 % of the regional populations, respectively. Most of the cetaceans potentially taken by Level B harassment are delphinids: bottlenose, Fraser's, pantropical spotted, and spinner dolphins as well as short-finned pilot whales are estimated to be the most common delphinid species in the area, with estimates of 59, 229, 346, 729, and 170, which would represent 0.04, 0.08, 0.08, 0.01, and 0.32% of the affected regional populations, respectively.

Encouraging and Coordinating Research

SIO and NSF will coordinate the planned marine mammal monitoring program associated with the proposed seismic survey with other parties that express interest in this activity and area. SIO and NSF will coordinate with applicable U.S. agencies (e.g., NMFS), and will comply with their requirements.

Negligible Impact and Small Numbers Analysis Determination

NMFS has defined ''negligible impact'' in 50 CFR 216.103 as "an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.'' In making a negligible impact determination, NMFS evaluated factors such as:

(1) The number of anticipated injuries, serious injuries, or mortalities;

(2) The number, nature, and intensity, and duration of Level B harassment (all relatively limited); and

(3) The context in which the takes occur (i.e., impacts to areas of significance, impacts to local populations, and cumulative impacts when taking into account successive/contemporaneous actions when added to baseline data);

(4) The status of stock or species of marine mammals (i.e., depleted, not depleted, decreasing, increasing, stable, impact relative to the size of the population);

(5) Impacts on habitat affecting rates of recruitment/survival; and

(6) The effectiveness of monitoring and mitigation measures.

As described above and based on the following factors, the specified activities associated with the marine seismic survey are not likely to cause PTS, or other non-auditory injury, serious injury, or death. The factors include:

(1) The likelihood that, given sufficient notice through relatively slow ship speed, marine mammals are expected to move away from a noise source that is annoying prior to its becoming potentially injurious;

(2) The potential for temporary or permanent hearing impairment is relatively low and would likely be avoided through the implementation of the shut-down measures;

No injuries, serious injuries, or mortalities are anticipated to occur as a result of the SIO's planned marine seismic surveys, and none are proposed to be authorized by NMFS. Table 3 of this document outlines the number of requested Level B harassment takes that are anticipated as a result of these activities. Due to the nature, degree, and context of Level B (behavioral) harassment anticipated and described (see "Potential Effects on Marine Mammals" section above) in this notice, the activity is not expected to impact rates of annual recruitment or survival for any affected species or stock, particularly given NMFS's and the applicant's proposal to implement mitigation, monitoring, and reporting measures to minimize impacts to marine mammals. Additionally, the seismic survey will not adversely impact marine mammal habitat.

For the other marine mammal species that may occur within the proposed action area, there are no known designated or important feeding and/or reproductive areas. Many animals perform vital functions, such as feeding, resting, traveling, and socializing, on a diel cycle (i.e., 24 hr cycle). Behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are more likely to be significant if they last more than one diel cycle or recur on subsequent days (Southall et al., 2007). Additionally, the seismic survey will be increasing sound levels in the marine environment in a relatively small area surrounding the vessel (compared to the range of the animals), which is constantly travelling over distances, and some animals may only be exposed to and harassed by sound for less than day.

Of the 26 marine mammal species under NMFS jurisdiction that may or are known to likely to occur in the study area, five are listed as threatened or endangered under the ESA:

humpback, sei, fin, blue, and sperm whales. These species are also considered depleted under the MMPA. Of these ESA-listed species, incidental take has been requested to be authorized for humpback, sei, fin, blue, and sperm whales. There is generally insufficient data to determine population trends for the other depleted species in the study area. To protect these animals (and other marine mammals in the study area), SIO must cease or reduce airgun operations if any marine mammal enters designated zones. No injury, serious injury, or mortality is expected to occur and due to the nature, degree, and context of the Level B harassment anticipated, and the activity is not expected to impact rates of recruitment or survival.

As mentioned previously, NMFS estimates that 26 species of marine mammals under its jurisdiction could be potentially affected by Level B harassment over the course of the IHA. The population estimates for the marine mammal species that may be taken by Level B harassment were provided in Table 3 of this document.

NMFS's practice has been to apply the 160 dB re 1 μPa (rms) received level threshold for underwater impulse sound levels to determine whether take by Level B harassment occurs. Southall et al. (2007) provide a severity scale for ranking observed behavioral responses of both free-ranging marine mammals and laboratory subjects to various types of anthropogenic sound (see Table 4 in Southall et al. [2007]).

NMFS has preliminarily determined, provided that the aforementioned mitigation and monitoring measures are implemented, the impact of conducting a low-energy marine seismic survey in the tropical western Pacific Ocean, September to October, 2013, may result, at worst, in a modification in behavior and/or low-level physiological effects (Level B harassment) of certain species of marine mammals.

While behavioral modifications, including temporarily vacating the area during the operation of the airgun(s), may be made by these species to avoid the resultant acoustic disturbance, the availability of alternate areas within these areas for species and the short and sporadic duration of the research activities, have led NMFS to preliminary determine that the taking by Level B harassment from the specified activity will have a negligible impact on the affected species in the specified geographic region. NMFS believes that the length of the seismic survey, the requirement to implement mitigation measures (e.g., shut-down of seismic operations), and the inclusion of the monitoring and reporting measures, will reduce the amount and severity of the potential impacts from the activity to the degree that it will have a negligible impact on the species or stocks in the action area.

NMFS has preliminary determined, provided that the aforementioned mitigation and monitoring measures are implemented, that the impact of conducting a marine seismic survey in the tropical western Pacific Ocean, September to October, 2013, may result, at worst, in a temporary modification in behavior and/or low-level physiological effects (Level B harassment) of small numbers of certain species of marine mammals. See Table 3 for the requested authorized take numbers of marine mammals.

Impact on Availability of Affected Species or Stock for Taking for Subsistence Uses

Section 101(a)(5)(D) of the MMPA also requires NMFS to determine that the authorization will not have an unmitigable adverse effect on the availability of marine mammal species or stocks for subsistence use. There is subsistence hunting for sperm whales, as well as other cetaceans and dugongs in Indonesia (Reeves, 2002; Marsh et al., n.d.). The hunting of Bryde's whales in the Philippines appears to be prohibited now, but dugongs are still taken there, as well as in Papua New Guinea (Marsh et al., n.d.). SIO and NMFS do not expect the proposed activities to have any impact on the availability of species or stocks of marine mammals in the study area for subsistence users that implicate MMPA section 101(a)(5)(D).

Endangered Species Act

Of the species of marine mammals that may occur in the proposed survey area, several are listed as endangered under the ESA, including the humpback, sei, fin, blue, and sperm whales. SIO did not request take of endangered North Pacific right whales due to the low likelihood of encountering this species during the cruise. Under section 7 of the ESA, NSF, on behalf of SIO, has initiated formal consultation with the NMFS, Office of Protected Resources, Endangered Species Act Interagency Cooperation Division, on this proposed seismic survey. NMFS's Office of Protected Resources, Permits and Conservation Division, has initiated formal consultation under section 7 of the ESA with NMFS's Office of Protected Resources, Endangered Species Act Interagency Cooperation Division, to obtain a Biological Opinion evaluating the effects of issuing the IHA on threatened and endangered marine mammals and, if appropriate, authorizing incidental take. NMFS will conclude formal section 7 consultation prior to making a determination on whether or not to issue the IHA. If the IHA is issued, NSF and SIO, in addition to the mitigation and monitoring requirements included in the IHA, will be required to comply with the Terms and Conditions of the Incidental Take Statement corresponding to NMFS's Biological Opinion issued to both NSF and SIO, and NMFS's Office of Protected Resources.

National Environmental Policy Act

With SIO's complete application, SIO and NSF provided NMFS a "Draft Environmental Analysis of a Low-Energy Marine Geophysical Survey by the R/V Roger Revelle in the Tropical Western Pacific Ocean, September-October 2013," prepared by LGL Ltd., Environmental Research Associates on behalf of SIO and NSF. The EA analyzes the direct, indirect, and cumulative environmental impacts of the proposed specified activities on marine mammals including those listed as threatened or endangered under the ESA. Prior to making a final decision on the IHA application, NMFS will either prepare an independent EA, or, after review and evaluation of the NSF and SIO EA for consistency with the regulations published by the Council of Environmental Quality (CEQ) and NOAA Administrative Order 216-6, Environmental Review Procedures for Implementing the National Environmental Policy Act, adopt the NSF and SIO EA and make a decision of whether or not to issue a Finding of No Significant Impact (FONSI).

Proposed Authorization

As a result of these preliminary determinations, NMFS propose to issue an IHA to SIO for conducting the low-energy seismic survey in the tropical western Pacific Ocean, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. The proposed IHA language is provided below:

Scripps Institution of Oceanography, 8602 La Jolla Shores Drive, La Jolla, California 92037, is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1371(a)(5)(D)), to harass small numbers of marine mammals incidental to a low-energy marine geophysical (seismic) survey conducted by the R/V Roger Revelle (Revelle) in the tropical western Pacific Ocean, September to October 2013:

1. This Authorization is valid from September 6 through November 12, 2013.

2. This Authorization is valid only for the Revelle's activities associated with low-energy seismic and sediment coring survey operations that shall occur in the following specified geographic area:

In the 10 sites in the tropical western Pacific Ocean located between approximately 4 to

8º South and approximately 126.5 to 144.5º East. Water depths in the survey area generally range from approximately 450 to 3,000 meters (m) (1,476.4 to 9,842.5 feet [ft]). The low-energy seismic survey will be conducted in international waters (i.e., high seas) and in the Exclusive Economic Zones (EEZ) of the Federated States of Micronesia (Micronesia), the Independent State of Papua New Guinea (Papua New Guinea), the Republic of Indonesia (Indonesia), and the Republic of the Philippines (Philippines), as specified in Scripps Institution of Oceanography's (SIO) Incidental Harassment Authorization application and the associated National Science Foundation (NSF) and SIO Environmental Analysis.

3. Species Authorized and Level of Takes

(a) The incidental taking of marine mammals, by Level B harassment only, is limited to the following species in the waters of the tropical western Pacific Ocean:

(i) Mysticetes – see Table 2 (attached) for authorized species and take numbers.

(ii) Odontocetes – see Table 2 (attached) for authorized species and take numbers.

(iii) If any marine mammal species are encountered during seismic activities that are not listed in Table 2 (attached) for authorized taking and are likely to be exposed to sound pressure levels (SPLs) greater than or equal to 160 dB re 1 μPa (rms), then the Holder of this Authorization must alter speed or course or shut-down the airguns to avoid take.

(b) The taking by injury (Level A harassment), serious injury, or death of any of the species listed in Condition 3(a) above or the taking of any kind of any other species of marine mammal is prohibited and may result in the modification, suspension or revocation of this Authorization.

4. The methods authorized for taking by Level B harassment are limited to the following acoustic sources without an amendment to this Authorization:

(a) A two Generator Injector (GI) airgun array (each with a discharge volume of 45 cubic inches [in^3]) with a total volume of 90 in^3 (or smaller);

(b) A multibeam echosounder; and

(c) A sub-bottom profiler.

5. The taking of any marine mammal in a manner prohibited under this Authorization must be reported immediately to the Office of Protected Resources, National Marine Fisheries Service (NMFS), at 301-427-8401.

6. Mitigation and Monitoring Requirements

The Holder of this Authorization is required to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable adverse impact on affected marine mammal species or stocks:

(a) Utilize one, NMFS-qualified, vessel-based Protected Species Observer (PSO) to visually watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during ramp-ups of airguns day or night. The *Revelle*'s vessel crew shall also assist in detecting marine mammals, when practicable. PSOs shall have access to reticle binoculars (7 x 50 Fujinon), big-eye binoculars (25 x 150), optical range finders, and night vision devices. PSO shifts shall last no longer than 4 hours at a time. PSOs shall also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior, when feasible.

(b) PSOs shall conduct monitoring while the airgun array and streamer(s) are being deployed or recovered from the water.

(c) Record the following information when a marine mammal is sighted:

(i) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and

(ii) Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or shut-down), Beaufort sea state and wind force, visibility, and sun glare; and

(iii) The data listed under Condition 6(c)(ii) shall also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

(d) Visually observe the entire extent of the exclusion zone (180 dB re 1 μPa [rms] for cetaceans; see Table 1 [attached] for distances) using NMFS-qualified PSOs, for at least 30 minutes prior to starting the airgun array (day or night). If the PSO finds a marine mammal within the exclusion zone, SIO must delay the seismic survey until the marine mammal(s) has left the area. If the PSO sees a marine mammal that surfaces, then dives below the surface, the PSO shall wait 30 minutes. If the PSO sees no marine mammals during that time, they should assume that the animal has moved beyond the exclusion zone. If for any reason the entire radius cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the exclusion zone, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 μPa (rms), SIO may start the second airgun without observing the entire exclusion zone for 30 minutes prior, provided no marine mammals are known to be near the exclusion zone (in accordance with Condition 6[f] below).

(e) Establish a 180 dB re 1 μPa (rms) exclusion zone for cetaceans before the two GI airgun array (90 in^3 total) is in operation. See Table 1 (attached) for distances and exclusion zones.

(f) Implement a "ramp-up" procedure when starting up at the beginning of seismic operations or anytime after the entire array has been shut-down for more than 15 minutes, which means starting with a single GI airgun and adding a second GI airgun after five minutes. During ramp-up, the PSOs shall monitor the exclusion zone, and if marine mammals are sighted, a shut-down shall be implemented as though the full array (both GI airguns) were operational. Therefore, initiation of ramp-up procedures from shut-down requires that the PSOs be able to view the full exclusion zone as described in Condition 6(d) (above).

(g) Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant exclusion zone. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the exclusion zone, further mitigation measures, such as a shut-down, shall be taken.

(h) Shut-down the airgun(s) if a marine mammal is detected within, approaches, or enters the relevant exclusion zone (as defined in Table 1, attached). A shut-down means all operating airguns are shut-down (i.e., turned off).

(i) Following a shut-down, the airgun activity shall not resume until the PSO has visually observed the marine mammal(s) exiting the exclusion zone and is not likely to return, or has not been seen within the exclusion zone for 15 minutes for species with shorter dive durations (small odontocetes) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales).

(j) Following a shut-down and subsequent animal departure, airgun operations may resume following ramp-up procedures described in Condition 6(f).

(k) Marine seismic surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant exclusion zones are visible and can be effectively monitored.

(l) No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant exclusion zone cannot be effectively monitored by the PSO(s) on duty.

7. Reporting Requirements

The Holder of this Authorization is required to:

(a) Submit a draft report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of the completion of the *Revelle*'s tropical western Pacific Ocean cruise. This report must contain and summarize the following information:

(i) Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings;

(ii) Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of shut-downs), observed throughout all monitoring activities.

(iii) An estimate of the number (by species) of marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) for cetaceans with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on modeled values for the two GI airgun array) to the seismic activity at received levels greater than or equal to 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) for cetaceans with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

(iv) A description of the implementation and effectiveness of the: (A) Terms and Conditions of the Biological Opinion's Incidental Take Statement (ITS) (attached); and (B) mitigation measures of the Incidental Harassment Authorization. For the Biological Opinion, the report shall confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act-listed marine mammals.

(b) Submit a final report to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, within 30 days after receiving comments from NMFS on the draft report. If NMFS decides that the draft report needs no comments, the draft report shall be considered to be the final report.

8. In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), SIO shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and Howard.Goldstein@noaa.gov and the NMFS Pacific Islands Region Marine Mammal Stranding and Entanglement Hotline at 1-888-256-9840 (David.Schofield@noaa.gov). The report must include the following information:

(a) Time, date, and location (latitude/longitude) of the incident; the name and type of vessel involved; the vessel's speed during and leading up to the incident; description of the incident; status of all sound source use in the 24 hours preceding the incident; water depth; environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); description of marine mammal observations in the 24 hours preceding the incident; species identification or description of the animal(s) involved; the fate of the animal(s); and photographs or video footage of the animal (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with SIO to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS via letter, email, or telephone.

In the event that SIO discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), SIO will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov and Howard.Goldstein@noaa.gov, and the NMFS Pacific Islands Marine Mammal Stranding and Entanglement Hotline (1-888-256-9840) and/or by email to the NMFS Pacific Islands Regional Stranding Coordinator (David.Schofield@noaa.gov). The report must include the same information identified in Condition 8(a) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether modifications in the activities are appropriate.

In the event that SIO discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 2 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO shall report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov and Howard.Goldstein@noaa.gov, and the NMFS Pacific Islands Marine Mammal Stranding and Entanglement Hotline (1-888-256-9840) and/or by email to the Pacific Islands Regional Stranding Coordinator (David.Schofield@noaa.gov), within 24 hours of the discovery. SIO shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

9. SIO is required to comply with the Terms and Conditions of the ITS corresponding to NMFS's Biological Opinion issued to both SIO, NSF, and NMFS's Office of Protected Resources (attached).

10. A copy of this Authorization and the ITS must be in the possession of all contractors and PSOs operating under the authority of this Incidental Harassment Authorization.

Information Solicited

NMFS requests interested persons to submit comments and information concerning this proposed project and NMFS's preliminary determination of issuing an IHA (see ADDRESSES). Concurrent with the publication of this notice in the Federal Register, NMFS is forwarding copies of this application to the Marine Mammal Commission and its Committee of Scientific Advisors.

Dated: May 31, 2013.

Helen M. Golde,
Deputy Director,
Office of Protected Resources,
National Marine Fisheries Service.

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